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1.—REPORT OF EXPLORATIONS IN COLORADO AND UTAH DURING THE SUMMER OF 1889, WITH AN ACCOUNT OF THE FISHES FOUND IN EACH OF THE RIVER BASINS EXAMINED.

BY DAVID STARR JORDAN.

[Plates I to V.]

INTRODUCTION.

Under the instruction of the U. S. Commissioner of Fish and Fisheries, Hon. Marshall McDonald, the writer undertook to make a series of examinations of the different streams of Colorado and Utah. This examination had two general purposes: First, to ascertain the general character of the streams of the Rocky Mountains and the Great Basin, their present stock of food-fishes, and their suitability for the introduction of species not now found there; second, to catalogue the fishes native to each stream, whether food-fishes or not, in order to increase our knowledge of the geographical distribution of each species and to throw further light on the laws which govern geographical distribution.

In the present paper is given an account of each stream, a list of the fishes found in it, and such notes, geographical or economic, as add to our knowledge of it.

In the work of the summer the writer had the very efficient help of his students, Prof. Barton W. Evermann of the Indiana State Normal School at Terre Haute, Mr. Bert Fesler of Topeka, Kans., and Mr. Bradley M. Davis of Chicago, Ill. The prosecution of the work was also materially aided by the help given by Mr. Richard Rathbun, assistant in charge of the work of scientific inquiry in the U. S. Fish Commission. We were also much indebted to several citizens of the regions visited for the interest they showed in our work and the help rendered by them. Of these we may mention especially Mr. George R. Fisher of Leadville, Hon. Gordon Land, fish commissioner of Colorado, Mr. Peter Madsen of Provo, Utah, and Mr. J. F. Brown of Blake City, Utah. Efficient help was also rendered by Col. John Gay, assistant to the U. S. Fish Commission, then in charge of the erection of the fish hatchery at Evergreen Lake, near Leadville.

The streams examined may be grouped as follows:

A.—Platte River:

- South Platte River, at Hartsel's Hot Springs, in the South Park.
- South Platte River, at Denver.
- Bear Creek, at Morrison.
- Boulder Creek, above Boulder.

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## B.—Arkansas River :

Arkansas River, near Leadville, Colo.  
 Lake Fork, near Leadville.  
 Evergreen Lakes, near Leadville.  
 Twin Lakes, at Interlaken, Colo.  
 Lake Creek, near Granite, Colo.  
 Arkansas River, at Cañon City, Colo.  
 Grape Creek, at Cañon City, Colo.  
 Arkansas River, at Good Night Ranch, near Pueblo, Colo.  
 Font-qui-Bouille Creek, at Manitou Springs.  
 Ruxton Creek, at Manitou Springs.  
 Fountain Creek, at Pueblo.  
 Arkansas River, at Coolidge, Kans.  
 Arkansas River, at Wichita, Kans. (Collections of Mr. Sherman Davis.)

## C.—Rio Grande :

Rio Grande, at Del Norte, Colo.  
 Rio Grande, at Alamosa, Colo.  
 Rio Conejos, at McIntire's Ranch, below Alamosa.  
 Rio Chama, at Chama, N. Mex.  
 San Luis Lakes, near Alamosa.

## D.—Colorado River :

Grand River, Glenwood Springs, Colo.  
 Sweetwater Lake, Eagle County, Colo.  
 Trapper's Lake, Garfield County, Colo.  
 Eagle River, at Gypsum, Colo.  
 Roaring Fork, above Glenwood Springs.  
 Cañon Creek, below Glenwood Springs.  
 Gunnison River, at Gunnison, Colo.  
 Tomichi Creek, at Gunnison, Colo.  
 Cimarron Creek, at Cimarron, Colo.  
 Gunnison River, at Delta, Colo.  
 Uncompahgre River, at Ouray, Colo.  
 Uncompahgre River, at Delta, Colo.  
 Green River, at Blake City, Utah.  
 Price River, at Castle Gate, Utah.  
 Rio de las Animas Perdidas, at Durango, Colo.  
 Mineral Creek, at Silverton, Colo.  
 Leitner's Creek, at Durango, Colo.  
 Rio Florida, near Durango, Colo.

## E.—Salt Lake Basin :

Utah Lake, at Provo, Utah.  
 Provo River, at Provo, Utah.  
 Jordan River, above Salt Lake City.  
 Great Salt Lake.

## F.—Sevier Lake Basin :

Sevier River, near Juab, Utah.  
 Chicken Lake, near Juab, Utah.

The following is, in brief, the itinerary of the summer's work :

*July 16.*—Left Bloomington in company with Prof. B. W. Evermann.  
*July 17.*—Joined at Kansas City by Mr. B. M. Davis.  
*July 18.*—At Coolidge, Kans.  
*July 19.*—Arrived at Pueblo, Colo.  
*July 20.*—Drove to Good Night Ranch ; seined the Arkansas River and Fountain Creek.

- July 22.*—At Cañon City; seined Arkansas River and Grape Creek.  
*July 23.*—At Granite; seined Lake Creek.  
*July 24.*—At Leadville; seined Arkansas River.  
*July 25, 26.*—Went to Twin Lakes with Col. John Gay and Mr. George R. Fisher; met Mr. Gordon Land; obtained specimens of trout of two varieties.  
*July 27.*—At Glenwood Springs; seined Roaring Fork and Grand River.  
*July 28, 29.*—At Gunnison; joined by Mr. Bert Fesler; Evermann and Davis remain a day at Gypsum.  
*July 30.*—At Gunnison; seined Gunnison River and Tomichi Creek.  
*July 31.*—At Cimarron; seined Cimarron Creek.  
*August 1, 2.*—At Delta; seined Gunnison and Uncompahgre Rivers.  
*August 4, 5.*—At Provo; seined Provo River and, assisted by Peter Madsen and his sons, drew a long net in Utah Lake.  
*August 6, 7.*—Salt Lake City; seined Jordan River.  
*August 9, 10.*—At Juab; seined Sevier River and Chicken Lake.  
*August 11, 12.*—At Green River (Blake City), Utah; seined the river, assisted by Mr. J. F. Brown.  
*August 13, 14.*—At Onray; examined Uncompahgre River.  
*August 15, 16.*—At Durango; seined Rio de las Animas Perdidas and Rio Florida.  
*August 17-19.*—At Alamosa, Colo.; Evermann and Fesler visit Del Norte, Colo.; seined Rio Grande, Rio Conejos, and San Luis Lakes.  
*August 20, 21.*—At Manitou Springs.  
*August 22.*—At Hartsel's Hot Springs; seined the South Platte.  
*August 23.*—At Denver; seined the South Platte.  
*August 24.*—At Boulder; seined Boulder Creek; Fesler and Davis visit Morrison, seining Bear Creek.  
*August 25.*—Left Colorado, reaching Bloomington, Ind., August 27.

## COLORADO.

The State of Colorado is for the most part an elevated and arid region, traversed by ranges of lofty mountains extending north and south, one of them being the main divide of the continent, which is nowhere crossed by streams.

In the eastern part of the State the mountains cease almost abruptly, and give place to the sage-plains, an elevated and nearly level region which slopes gradually eastward through Kansas and Nebraska to the Missouri River. This region has in Colorado little rain-fall. Its vegetation is scanty, except along the streams, where the soil may be made very fertile by irrigation. In the central part of the State elevated and arid valleys rendered fertile by irrigation lie between the mountain chains. On the north slopes of mountains, especially northward, are considerable pine forests, while above the timber line are level grassy areas, mountain meadows, well watered and with a profusion of wild flowers. The mountain chains also sometimes inclose large flat green areas, many of them former lake beds, which have become filled with sediment and the débris of vegetation. These are known as parks, and in these the clear mountain streams pursue courses with interminable meanderings and with but slight current.

In the western part of Colorado the great folds of the granite mountains give place largely to horizontal strata. Here erosion of water on a grand scale has filled this region with gorges, the intervening rocks being left as mesas and buttes. In one case, the Grand Mesa stands at a height of nearly a mile above the Gunnison River at Delta, the top of the mesa being reached by some seven or eight successive stairs, each representing a separate plane of erosion.

In the northwestern part of Colorado are many clear lakes of glacial origin, but in the rest of the State the lakes are comparatively few.

Most of the streams of Colorado rise in springs in or above the mountain meadows, many of them having their origin in banks of snow, which the clear weather of summer is not sufficient wholly to melt.

These streams are clear and very cold. In their descent from the snow-banks they are brawling and turbulent, often so much so as to be unfitted for fish life. In their course through the mountain meadows (very similar to the "Alp" pastures of Switzerland) the streams are usually of gentle current, with many windings and with occasional deep holes beloved of trout. Lower down most of them pass to the valleys through deep cañons, some of them very deep and with many rapids. Vertical falls are, however, very rare in Colorado, and most of these cañons form no obstacle to trout. Below the cañons, the stream, still clear and cold, enters the valley, where the flat bottom is usually covered deep with sediment which the streams bring down.

Here the water grows warmer, the fine silt renders it more or less turbid, and at last it becomes unfit for trout and at the same time suitable for the suckers and chubs. In the winter and spring the water is cold and clear for some distance down the valleys. In these seasons the trout extend their range to a corresponding degree. In the summer and fall they are more or less confined to the mountains or the cañons. Often the stream after entering the valley cuts its way through a moraine deposit. In that case its course is filled with boulders, and its waters are sometimes as brawling in a boulder-strewn valley as in the mountains.

In some cases placer-mining and stamp-mills have filled the waters of otherwise clear streams with yellow or red clay, rendering them almost uninhabitable for trout. Parts of the upper Arkansas and Grand Rivers have been almost ruined as trout streams by mining operations. In a few streams the presence of iron springs seems to exclude all fishes.

After reaching the base of the mountains the streams flow with little current over the ill-defined beds across the plains. They tear up the fine soil and shift it from place to place. Occasional rains swell the dry beds of "Sand-Arroyos;" the stream becomes more and more charged with clayey sediment, and in time not one of these rivers would be recognized as the crystal-clear stream which came down the mountains. The Platte spreads out broad and shallow over the plain, and its course is full of quicksands. Its banks are rarely well defined. The Arkansas resembles the Platte, being even more muddy, however, and the Rio Grande is similar to it. The Colorado carries the peculiar erosion of the mesas to a still greater extent as it goes southward. The stream is large and swift, with treacherous currents and shifting bottom. As no rain-fall or frosts wear away its banks, it sinks deeper and deeper below the surface, until it forms the deepest gorge in the world, with banks which are vertical or like stair-cases.

In the progress of settlement of the valleys of Colorado the streams have become more and more largely used for irrigation. Below the mouth of the cañons dam after dam and ditch after ditch turn off the water. In summer the beds of even large rivers (as the Rio Grande) are left wholly dry, all the water being turned into these ditches. Much of this water is consumed by the arid land and its vegetation; the rest seeps back, turbid and yellow, into the bed of the stream, to be again intercepted as soon as enough has accumulated to be worth taking. In some valleys, as in the San Luis, in the dry season there is scarcely a drop of water in the river-bed that has

not from one to ten times flowed over some field, while the beds of many considerable streams (Rio la Jara, Rio Alamosa, etc.) are filled with dry clay and dust.

Great numbers of trout, in many cases thousands of them, pass into these irrigating ditches and are left to perish in the fields. The destruction of trout by this agency is far greater than that due to all others combined, and it is going on in almost every irrigating ditch in Colorado.

It is not easy to suggest a remedy for it. The valleys in question would be worthless for agriculture were it not for irrigation, and the economic value of the trout is but a trifle as compared with the value of the water privileges. It is apparently impossible to shut out the trout from the ditches by any system of screens. These screens soon become clogged by silt, dead leaves, and sage brush, and thus will not admit the passage of the water.

Perhaps most of the trout are lost by entering the ditches in the fall, when running down stream with the cooling of the water. It has been suggested that a law could compel the closing of the ditches after the harvest, allowing the streams to flow freely until March or April. In the fall the water is worth most to the fishes and least to the farmers. I am unable to say whether this plan will prove practicable or effective. This is certain, that if the present conditions go on the trout in the lower courses of all the streams will be exterminated, and there will be trout only in the mountain lakes and in the mountain meadows, to which agriculture can not extend.

#### INDIGENIOUS FISHES.

The fishes of Colorado are very few in number, notwithstanding the fact that four distinct faunal basins are within the limits of the State.

The trout, *Salmo mykiss* Walbaum, and its varieties are found in all the mountain lakes and streams, down to a point where the summer temperature reaches 60° to 65°, when they gradually disappear. In clear streams and streams with bottoms of gravel they extend much farther than in turbid streams or those with clay bottoms.

The mountain minnows, *Rhinichthys dulcis*, on the eastern slope and in the Rio Grande, and *Agosia yarrowi*, in the Colorado basin, accompany the trout in the mountain meadows, not, however, ascending so near to the sources of the stream. On the other hand, they extend their range farther down than the trout, and exist in millions in the upper part of some of the valleys. They seem to be harmless little fishes, and they are eaten by the trout.

The blob or Miller's Thumb (*Cottus bairdi punctulatus*) is equally fond of cold and clear waters. In the Colorado basin it is very abundant, but in the other regions it is scarce, if present, and we did not find it. It is very destructive to the eggs of trout.

The suckers of various species extend up the rivers more or less to the point where the trout disappear. Generally speaking, the suckers of the different basins are unlike. We found *Catostomus griseus* and *Catostomus teres* in the Platte, the former ascending the streams much higher than the latter. In the Arkansas, *Catostomus teres*; in the Rio Grande, *Pantosteus plebeius*; in the Colorado, *Pantosteus delphinus*, *Catostomus latipinnis*, and *Xyrauchen cypho*. The species of *Catostomus* and *Xyrauchen* reach a considerable size, and are food-fishes of poor quality. All are destructive to the eggs of the trout.

More destructive, however, are the chubs (*Leuciscus*). Of these, none ascend to the mountains in the Arkansas or the Platte. But, in the Rio Grande, one species, *Leuciscus pulcher*, exists in abundance, while in the Colorado, the Round-Tail (*Gila robusta*) is equally common. Another chub-like fish in the Colorado, *Ptychocheilus lucius*, reaches a great size, the largest of all the *Cyprinidae*, and in default of better fish, assumes economic importance.

Other minnows ascend the Arkansas and Platte, though only to the foot of the mountains. Most of these are of species common in the Mississippi Valley. The bulk of the rich fauna of the Mississippi is however excluded from Colorado, because the species can not ascend the turbid waters of the lower Arkansas or Platte.

The darters, sunfishes, and catfishes can hardly be said to belong to Colorado, as nearly all the species are shut out by the unfit character of the lower streams. These were seen by us only about Denver and Pueblo. In a similar way most of the Texan fishes are excluded from the Rio Grande.

#### INTRODUCED FISHES.

The Eastern brook trout (*Salvelinus fontinalis*) has been introduced into numerous streams (Bear Creek, Twin Lakes, Echo Lake in Egeria Park, Runyon Creek, Tomichi Creek, etc.). It does well everywhere, and is said to grow more rapidly than the native trout, but this statement is denied by some partisans of the latter fish.

The rainbow trout of California (*Salmo irideus*) has been sparingly introduced, and is reported to do well. One specimen was obtained by us in Twin Lakes.

The land-locked salmon of Maine (*Salmo salar sebago*) has been introduced into Twin Lakes, where specimens are occasionally taken.

A number of carp-ponds also exist in the State.

As an addition to the above list, I would strongly recommend the introduction of the larger catfishes, especially *Leptops olivaris*, *Ictalurus punctatus*, and *Ameiurus nebulosus*, into the tributaries of the lower Colorado, as the Green River and the San Juan. Food is abundant, and every condition seems to be favorable for them, while the whole great basin of the Colorado contains, excepting the trout, no fish of even second-rate character as food for man.

#### A.—THE PLATTE BASIN.

The South Platte rises in the elevated plateau known as the South Park. Through the park it flows in an undulating course over grassy fields, finally breaking through the mountains to the sage plains above Denver. It receives many tributaries from the mountains, and the waters of numerous sandy runs, dry in summer, pour in from the plains. Its water, both above and below Denver, is largely used for irrigation. Thus it becomes a shallow, muddy stream, with sandy bottom and very low banks. In the northeastern part of Colorado it meets its fellow, the North Platte, a stream of similar character, rising in the North Park. The Platte, now a broad, very shallow stream, full of sandbars and quicksands, flows eastward across Nebraska to the Missouri. The fishes of the Platte, as far up as Denver, are mostly the ordinary species of the upper Missouri region. The trout do not descend below the level of the parks, and are scarce even in the South Park itself, being chiefly confined to the mountain gorges above it.

Collections were made at the following points :

1. *Hartsel's Hot Springs*, in the South Park, about 15 miles below the foot of the Park Range.—The South Platte here flows through grassy meadows, a fairly clear stream, a little soiled by the seepage from the irrigating ditches. Water rather cold, about 65°. In summer the stream is about 10 feet broad, 2 to 3 feet deep, with many deep holes in its windings. It is literally full of suckers (*Catostomus griseus*). *Rhinichthys dulcis* is also abundant, but no other species were seen. Trout are found in the mountains above and frequently descend to the level of the park where they are carried out over the fields by the irrigating ditches. It is said that a washtub full of young trout were picked up from the ditch at Hartsel's last fall. Species from this locality are marked H.

2. *Denver*.—Collections were made in the Platte at the bridge just below the mouth of Bear Creek, 6 miles above Denver. The river is there 1 to 6 rods wide and 2 to 4 feet deep. Temperature about 72°. The water is grayish or brownish, nearly clear, with a bottom of gravel and sand. Fishes are very abundant, nine species being taken. These are marked D in the following list.

At its mouth, Bear Creek is clear, but very warm, the water being all seepage from irrigating ditches. It contains the same species as the river.

3. *Bear Creek*, above Morrison.—Seined at a point 10 miles up the cañon from Morrison, near Hines's. The stream is here about 20 feet wide and 3 feet deep. The water is clear and swift, with a bottom of gravel and boulders. Temperature about 67°. Trout are here abundant, both the native and the Eastern brook trout, which has been introduced. The suckers and minnows are the same as at Hartsel's. The species taken at Morrison are marked M.

4. *Middle Boulder Creek*, above Boulder.—Examined at various places in Boulder cañon to a point 12 miles above Boulder. A swift, clear, very cold (54°) mountain stream, full of rapids and deep pools. The bottom is everywhere made up of boulders, so that a net could not be used. It is said that trout are abundant in the upper part of the cañon, and that the fishing is especially good in the mountain pastures above the top of the cañon. The only fishes taken were young suckers, marked B in the following list :

#### FISHES OF THE PLATTE BASIN.

1. *Catostomus teres sucklii* (Girard). D.

Abundant at Denver.

2. *Catostomus griseus* (Girard). D., H., B., M.

Abundant everywhere, but especially so in the upper courses of the streams. D. 10. Scales 102. About six rows of tubercles on upper lip. Dorsal not nearer base of caudal than snout, except in the larger specimens. Lower lip with a slight cartilaginous sheath. Body long and low, dusky above, paler below. As already noticed in a paper on the fishes of the Yellowstone Park, this species seems to be the same as *Acomus lactarius* Girard and *Catostomus retropinnis* Jordan. It appears to differ from *C. catostomus* (Forster) in the greater number of rows of tubercles on the upper lip and in the greater inequalities of the scales on the body. But our specimens of *C. catostomus* are not numerous enough to test fully the value of these characters, and further study may show that this form intergrades with the other.

3. *Hybognathus nuchalis* Agassiz (? var. *placita* Girard). D.

Rather rare about Denver. The specimens are all somewhat stout in form, the nose a little blunter than usual and rather less projecting beyond the mouth. Color very dark, the scales dark edged, and a dark lateral shade. Suborbitals very narrow. Eye 4 in head.

These specimens may belong to the form called *placita*, but the distinctions of varieties and species in this group are very unsatisfactory.

4. *Notropis scylla* (Cope). D.

A few specimens from Denver, similar to others from Pueblo.

5. *Notropis gilberti* Jordan and Meek. D.

Very abundant at Denver. These specimens agree closely with the original types from the Des Moines River at Ottumwa, indicating that the species has a wide distribution over the western plains. The species has the lips somewhat thickened, and there is a little fleshy projection at the corner of the mouth, not, however, amounting to a barbel. A little dusky shade on each side of the dorsal fin seems to be characteristic. *Photogenis piptolepis* Cope may be this species, but the description is not sufficiently full to permit identification.

6. *Notropis megalops* (Rafinesque). D.

Not common; apparently typical, scales before dorsal 23.

7. *Notropis lutrensis* (Baird & Girard). D.

Not common; similar to Iowa specimens. Scales 33.

8. *Semotilus atromaculatus* (Mitchill). D.

Common. Scales 60. Similar to Indiana examples.

9. *Rhinichthys dulcis* (Girard). H., D., M. (*Rhinichthys maxillosus* and *transmontanus* Cope. *Rhinichthys ocella* Garman.)

The *Rhinichthys* of the Rocky Mountain region strongly resembles the eastern *R. cataracte*. It, however, differs constantly in the insertion of its dorsal, the front of the dorsal being midway between the base of the caudal and the nostril, while in *R. cataracte* the base of the dorsal is almost midway between the base of the caudal and the tip of the snout. *R. dulcis* is usually rather more slender than *R. cataracte* and has a sharper snout. It does not usually reach as large a size as the latter species. No difference in the fins; scales or coloration seem to be permanent.

The *Rhinichthys* of the upper Missouri, Arkansas, and Platte seems to be the same. That of the upper Rio Grande, called *R. transmontanus* by Professor Cope, is not evidently different. The species found in the Utah Basin (*R. luteus* Garman) has, as a rule, two or three more scales in a vertical row from dorsal to ventrals, twelve to fourteen below lateral line in *luteus*, ten or eleven in *dulcis*. But this character is variable and of rather doubtful value, and no other difference is apparent.

10. *Zygionectes floripinnis* (Cope). D.

One specimen taken, agreeing with Cope's description. Outer teeth long, well separated. Scales 31-10. D. 10. Scales of back much punctulate with black.

11. *Etheostoma nigrum* Rafinesque. D.

Abundant, apparently like Iowa specimens. D. IX-12. Scales 47.

12. *Salmo mykiss stomias* Cope. M.

Abundant in the Park Range and in mountain streams generally.

## B.—ARKANSAS BASIN.

The Arkansas River rises in the mountains to the north of Leadville. It flows southward through a broad park-like valley, grassy in its upper part and becoming arid lower down. This valley is bounded on either side by lofty mountains, with snow-banks which are the source of many ice-cold streams. At Salida the river turns abruptly to the east, breaking through the mountains in a deep and rocky cañon, by which it reaches the level of the sage plains. Throughout the region above the cañon the Arkansas is clear and cold, in every way well suited for trout. Placer-mining at Leadville and Granite has much reduced the number of fishes in the river by filling the water with clay, but they still abound in all the tributary streams. Below the cañon the river becomes warmer and more muddy, and no trout are found there, the fauna from Cañon City down being much the same as that of the rivers of Kansas. The fishes of the Arkansas were examined at the following points:

1. *Arkansas River* and its Lake Fork near Leadville. (Seined at a bridge across Lake Fork between Evergreen Lakes and the village of Malta, about 3 miles west of Leadville.)—The river and the Lake Fork are about equal in size and entirely similar in character, flowing with a moderate current through green meadows, shaded by willows, and with occasional deep holes in the bends. The streams are each about 15 feet wide and the bottom is gravelly. The temperature is about 62°. These streams are ideal trout-brooks. Trout are very abundant and with them *Rhinichthys dulcis*. Species taken at Leadville are marked L in the following list.

2. *The Evergreen Lakes* are a series of trout-ponds, wholly or partly artificial, fed by cold streams from the flanks of Mount Massive. One of these streams, having its rise in the largest permanent snow-field in Colorado, has been chosen by the U. S. Fish Commission as the site of its hatchery. No better location could be desired.

3. *Twin Lakes*.—These two lakes, formed by a moraine-dam at the foot of Mount Elbert and Mount Grizzly, are the largest lakes on the east side of the divide in Colorado. The two lakes are separated also by a moraine, across which they are connected by a short stream, perhaps an eighth of a mile long. The lower lake is the larger of the two, and is about 3 miles long by 2 wide. The upper is about 1½ miles by 2. The lower lake is said to average 40 feet in depth, its lower part being extensively shallow, the middle and the south side very deep. The bottom is largely gravelly and covered with water plants. In some places are piles of boulders. The shallow north side of the lake is full of *Najas* and other water weeds, growing 3 to 5 feet high in water 10 feet deep. Among these plants the trout chiefly feed. In them they often escape after taking the fly by breaking the leader. "Shrimps" (*Gammarus*) are very abundant in the weeds. The upper lake is a little colder and not quite so well stocked with fish. Its area is about one-half that of the lower lake. Our collections were made in the lower lake, most of the trout being taken with the fly by Mr. George B. Fisher. Besides the two forms of trout, the lake contains suckers (*C. teres*) and *Rhinichthys duleis*. Species from Twin Lakes are marked T in the list. The inlet of the upper lake is a very clear, cold stream of considerable size. A water-fall in this stream formerly checked the ascent of the trout, but it has now been destroyed by blasting.

4. *Lake Creek* near Granite.—Lake Creek, the outlet of Twin Lakes, is a very clear stream with green borders running across a desolate mesa, a glacial moraine, down to

the Arkansas River. It is about 2 rods wide and 2 to 4 feet deep. The temperature is about 73°. Its bottom is gravelly, rarely sandy, with some deep holes and with few water plants. Fishes are not plenty. Most were caught at the bridge, midway between the lakes and the Arkansas River, and about 1½ miles from either. The creek contains trout, suckers, and *Rhinichthys*, marked G in the list.

5. *Arkansas River* at Cañon City.—At Cañon City, at the foot of its great cañon, the river is somewhat turbid and has a temperature of 70°. The stream is rather swift, with gravelly bottom and no weeds. The bottom is muddy in places, doubtless from the placer mining above. The cañon marks the lower limit of the trout and the upper limit of the fishes of the plains. Fishes are scarce in the river here, the four species seen being marked A in the list.

6. *Pond at Cañon City*.—Opposite Cañon City is a small clear pond fed by sweepings from irrigating ditches, full of chara and other weeds. The water is warm, temperature 80°, and the pond and its small outlet is full of small fishes. The pond is 2 rods long and 3 feet deep. The species taken here are marked C in the list below.

7. *Grape Creek* above Cañon City.—Grape Creek is a small but long stream, rising in the Wet Mountain range, flowing in a narrow valley with precipitous walls, and emptying into the Arkansas from the south 2 miles above Cañon City. The water is clear and cold, temperature 66°. The current is swift and the bottom of sand and gravel without weeds. It is about 6 feet wide, 12 inches deep, with a few pools. In the deep places is *Rhinichthys dulcis*. No other fishes were seen. It is said that trout occur some 18 miles up the creek, but not in abundance. Four-Mile Creek, below the town, is a similar stream. Some seventeen years ago, we are informed, this stream was full of trout, but in a dry summer it was reduced to a series of pools. The settlers gathered the trout then with dip-nets and the herons took all that were left. Since then no trout have been seen there.

8. *Arkansas River* at Pueblo.—At Pueblo the river becomes warm, 80°, and dark gray in color. It is about 4 rods wide and 2 to 5 feet deep, with swift current. The bottom is gravelly, with stretches of gray mud. There are no deep pools or quiet reaches and no water plants. Fishes are plentiful, especially in the shoals. Collections were made at Good Night Ranch, 5 miles west of Pueblo, above and below Mr. Bell's residence. Close along the river the banks are green, but the region about is a hot, barren mesa, with scanty vegetation. Fishes from Pueblo are marked P in the list which follows.

9. *Fountain Creek* at Pueblo.—Fountain Creek is a long stream rising in the mountain brooks about Pike's Peak. It is formed at Manitou Springs by the union of two streams, the Ruxton, rising on Pike's Peak, and the Font-qui-Bouille, which rises in Ute Pass. The Ruxton, a mountain torrent, is without fish, but into a tributary pond eastern trout have been introduced. The Font-qui-Bouille, also without fish, has in its course both iron springs and water-falls. The iron springs give the water a red tinge. The waters of Fountain Creek are chiefly consumed by the irrigating ditches. At Pueblo it is a clear shallow stream, 6 feet wide by 4 inches deep, in a wide sandy bed. Temperature, 70°. Species from Fountain Creek are marked F.

10. *Arkansas River* at Wichita, Kans.—A collection comprising 27 species was made for us at Wichita by Mr. Sherman Davis. The river at Wichita is broad and muddy, with soft bottom, and the species obtained are mostly those of the muddy or sandy prairie streams of Kansas.

## FISHES OF THE ARKANSAS BASIN.

## A.—UPPER ARKANSAS ABOVE THE CAÑON.

1. *Catostomus teres sucklii* Girard. G., T. (*Catostomus allicolus* Cope; *Moxostoma trisignatum* Cope.)

Abundant in Lake Creek, and more or less common in the Twin Lakes. Similar to ordinary eastern specimens—var. *teres*—except that the lips are larger, and the upper lip has from four to six rows of papillæ. The fish called *Catostomus sucklii* by Girard belongs to this type, which may be known as var. *sucklii*.

2. *Rhinichthys dulcis* (Girard). L., T., G.

Abundant in all the streams tributary to the Upper Arkansas, in company with the trout, although not ascending the brooks as far as the lakes.

3. *Cottus* sp.

It is said that a species of *Cottus* is occasionally found in the Upper Arkansas, but we saw no specimens.

4. *Salmo mykiss macdonaldi* (Jordan and Evermann). The yellow-finned trout of Twin Lakes. (Plate I, Fig. 1.)

Besides the common green-back trout another trout has long been known to anglers to exist in Twin Lakes, and Messrs. Gordon Land and George R. Fisher have in one way or another at different times called attention to it.

Mr. Fisher accompanied me from Leadville in search of the fish, and a morning of fly-fishing secured for us about ten fine specimens. These represent a very distinct form or variety of the mountain trout, which we recognize as a distinct subspecies under the name of *Salmo mykiss macdonaldi*. We have taken pleasure in naming the yellow-fin for the U. S. Fish Commissioner, the Hon. Marshall McDonald, in recognition of his services in connection with the propagation of the American Salmonidæ.

It is not unlikely that this may prove to be a desirable variety for introduction into gravelly ponds and lakes in other regions.

*Description*.—Head, 4 to 4 1.10 in length; depth, 4 1.5 to 5. D. 2, 12. A. 1, 11. B. 10. Scales, 40–184–37; about 125 peres. Length of types, 6 to 10 inches.

Body more elongate and more compressed than usual among the trout. Head long, compressed, the snout moderately pointed; mouth rather large, the jaws subequal, the maxillary extending beyond the eye,  $1\frac{3}{4}$  to 2 in head; hyoid teeth present, small; opercle longer than usual, its greatest length  $4\frac{1}{3}$  in head, somewhat greater than eye, its posterior margin strongly convex. Eye  $5\frac{1}{3}$  in head; snout  $4\frac{1}{8}$ ; gill-rakers short,  $x + 10$  in number.

Scales quite small and regularly placed. Pectoral fin moderate,  $1\frac{3}{8}$  in head; ventrals 2. Caudal moderately emarginate, the lobes equal,  $1\frac{3}{8}$  in head.

Color, silvery olive; a broad lemon yellow shade along the sides, lower fins bright golden yellow in life, no red anywhere except the deep red dash on each side of the throat, which is never wanting in *Salmo mykiss*. Body posteriorly and on dorsal and caudal fin profusely speckled with small pepper-like spots, smaller than the nostril and smaller than in any other of the forms of the *Salmo mykiss*. Occasionally these spots extend forward to the head, but they are usually sparse on the anterior half of the body.

The yellow-fin trout is largely on the gravels and about the north or sunny side of the lake. It is not often taken in deep water.

It spawns in spring, and the suckers devour the spawn in the streams and spawning beds. The trout, however, feeds freely on young suckers, and sometimes on young trout.

This species has the lower fins bright yellow; there is a broad yellowish lateral shade, by which the species can be recognized in the water. The black spots are numerous and very small. There is little red under the throat and none at all elsewhere. The flesh is paler and more watery than that of the green-back trout, which is usually regarded as the better food-fish. This paleness of color may be associated with its feeding habits, the trout which feed on crustacea having the redder flesh.\*

5. *Salmo mykiss stomias* (Cope). Green-back Trout. (Plate I, Fig. 2.)

This trout is very common in all the upper tributaries of the Arkansas River and in the Twin Lakes. From the common trout of the upper Missouri region it seems to differ somewhat, being of a greener color, with less red, and with redder flesh, all matters of very slight importance from the point of view of the systematist. The black spots are larger than in any other of our trout. The mouth is rather small and the scales are smaller than usual among these trout.

These facts seem to indicate a distinction from the ordinary *Salmo mykiss* sufficient to justify the recognition of a subspecies, although the differences are small, and some of them may be inconstant. The trout taken by us in tributaries of the Platte seems to be identical with the "green-back trout" of the Arkansas. The name *Salmo stomias* was given by Cope to specimens at first stated by him to have come from the "Platte River, at Fort Riley." Later he stated that these came "not from the Platte, but from the Kansas, a very different river." Fort Riley is a town on the Kansas River, east of the center of the State of Kansas. The Kansas River rises in the sage plains of Eastern Colorado. It contains no trout anywhere. In fact, there are probably no waters in which trout can live within 500 miles of Fort Riley. It is safe to presume that the types of *Salmo stomias* did not come from Fort Riley. It is probable that

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\* Since this report was sent to the printer, I have received from Mr. George R. Fisher, of Leadville, a very fine specimen of the yellow-fin trout. Mr. Fisher writes under date of June 2, 1890:

"I returned to Leadville in the spring and was here when the yellow-fins gathered at the mouth of the creeks immediately after the ice left the lakes waiting for the first rise in the streams. They appeared in schools at first but as the water raised they paired off, and went to the spawning beds in pairs.

"Before they mated they would take a trolling spoon or fly, and I believe grubs or minnow bait, but after pairing (they were nearly ready to spawn then) they would take nothing, and could only be taken with a grab-hook or spear. The largest yellow-fin taken this spring of which I know personally weighed 8 pounds 11½ ounces, and I believe that was the heaviest taken. This fish had been dressed before I knew of its capture or I would have sent it to you.

"I got one from two fishermen named Tyler and McDonald which weighed something over 7 pounds when first taken from the water, though I can't give the exact weight. This fish I have put in alcohol sealed up in a tin box and sent to you by express.

"It was kept on ice four days before putting in the alcohol and weighed at that time 6 pounds 14 ounces.

"This weight was carefully made and I know was correct.

"I have kept the fish here just one week since it was put in the alcohol and I see it has lost a good deal of the yellow color on the fins and throat."

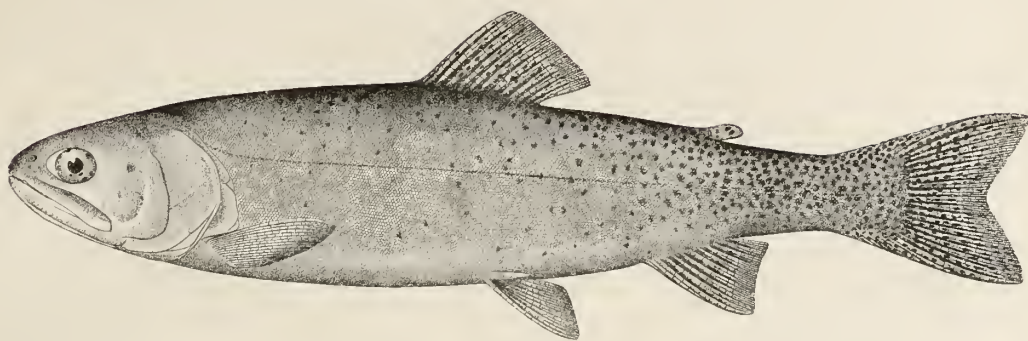


FIG. 1. YELLOW-FINNED TROUT (*Salmo mykiss macdonaldi*). (See page 11.)

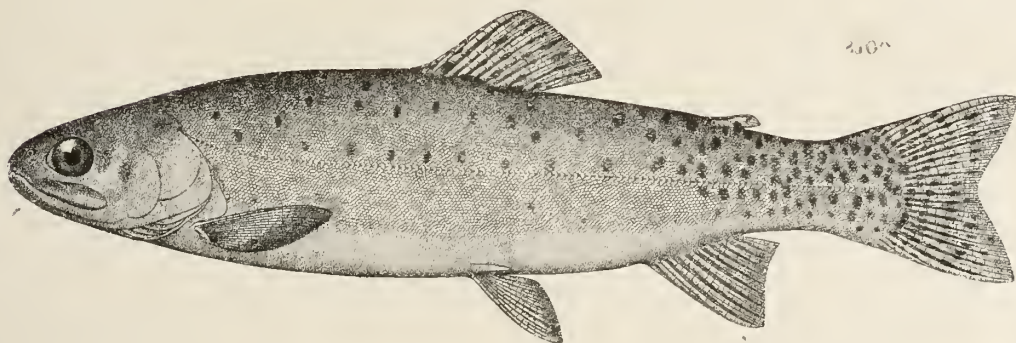


FIG. 2. GREEN-BACK TROUT (*Salmo mykiss stomias*). (See page 12.)



FIG. 3. RED-THROATED TROUT (*Salmo mykiss*). (See page 13.)



they came from some point on the South Platte, and on this supposition I have adopted the name *stomias* for the trout of the Platte.

The green back trout seldom exceeds three-fourths of a pound in weight. It is very abundant in the streams of the Upper Arkansas as well as in the Twin Lakes. It spawns in spring, in snow-water if possible, and it will leave spring-water to find snow-water. In winter, however, they seek for warmer waters. It is said that when the winter breaks up, the trout are too blind to see bait. In color, the green-back is green, or even almost black on the back. The lower fins and the throat are bright red, but there is not much trace of the red lateral band. The black spots are large and mostly confined to the posterior part of the body. In some cases these spots are ocellated with paler. At the spawning time, in May and early June, the males have much red, but later the sexes become similar. In specimens found about pools, there is often much red even in the summer. Those from the deeper parts of the lakes are always bright green, with a little red.

At the hatchery of Dr. Laws it appears that this trout will not willingly eat young suckers or minnows, its food being largely young crustacea.

The flesh in these trout is extremely red, this color being probably heightened by the character of its food. In the specimens from Arkansas River the body is plumper and softer than in those from Twin Lakes.

In connection with our study of these two forms I have had occasion to compare a large number of trout from various streams in the Rocky Mountains and westward. Besides the rainbow trout, *Salmo irideus*, which is chiefly confined to California, and the steel-head trout, *Salmo gairdneri*, found chiefly about the river-mouths in Oregon and northward, both of which species are characterized by the large size of the scales (from 130 to about 140), all our other western trout of the genus *Salmo* seem to belong to a single species. For this species the oldest scientific name is that of *Salmo mykiss* Walbaum (1792). To this name *Salmo purpuratus* (Pallas, 1811) and *Salmo clarkii* (Richardson, 1836) must give precedence.

This species is distributed from Kamtschatka and Alaska, southward to the mountains of Chihuahua, and eastward along the flanks of the Rocky Mountains so far as the clear water of the mountain goes. It seems to be absent in southern California, its place being taken by the *irideus*, but in all other suitable waters, excepting some streams in northwestern Wyoming, where water-falls keep it back, this trout may be found.

Several well-marked varieties occur in isolated lakes, and in general large streams or streams with a large food supply yield larger trout than small streams or streams with scanty food. All forms of *Salmo mykiss* have distinct hyoid teeth in life. All have a red dash below the lower jaw, from which comes the vernacular name of "cut-throat trout," and all show a small diffuse dark spot behind the eye.

A comparison of many specimens leads us to the recognition of the eight sub-species or varieties besides two others which I am scarcely able to define. It will be interesting to find out to what extent these forms will interbreed, and to what degree their peculiar characters will prove to be permanent when they are transplanted to other waters.

a. *Salmo mykiss* (Walbaum.) (Plate I, Fig. 3.)

The typical (*i. e.*, first known) form of the species, found in the waters, both fresh and salt, of Alaska and Kamtschatka.

Large, black-spotted, both fore and aft, and reaching a weight of 10 to 25 or 30 pounds. Sea-run specimens are much paler in color and grow larger.

b. *Salmo mykiss clarki* (Richardson). "Cut-throat Trout."

The common trout of both sides of the Cascade Range, profusely and usually rather finely spotted, the spots scarcely more numerous behind than before.

c. *Salmo mykiss lewisi* (Girard). Trout of the Upper Missouri. (Plate II, Fig. 4.)

This large trout seems to have the spots, on the average, larger than on those west of the mountains, but even this difference is questionable, and doubtless neither form requires a varietal name.

d. *Salmo mykiss henshawi* (Gill and Jordan). The trout of Lake Tahoe and neighboring waters. (Plate II, Fig. 5.)

A fine large trout, distinguished mainly by its longer and more conical head. Spots large, equally distributed, extending on head and belly. Scales rather small, about 180.

e. *Salmo mykiss pleuriticus* (Cope). Colorado River Trout. (Plate II, Fig. 6.)

The common trout of the basin of the Colorado, its range extending to the mountains of Arizona. Variable in color, size, and form, with its surroundings, and in most respects substantially identical with *lewisi*, the chief difference being that in this form, as in *spilurus*, *stomias*, and *macdonaldi*, the black spots are usually much more numerous on the posterior part of the body, while the head is usually free from spots. This is, however, not universally true.

In one specimen, from Trapper's Lake, the entire body from head to tail is closely and coarsely spotted. Generally the black spots are rather large, but in some specimens the spots are small, smaller than in any of the other forms except var. *macdonaldi*.

In a considerable number taken in Eagle River, Colorado, the spots are as small and as close set as in var. *macdonaldi*, and the usual red color of the lower fins is in these specimens changed to pale orange.

Although the coloration is almost that of *macdonaldi*, there are other differences, the most notable being in the short opercle,  $4\frac{2}{3}$  to 5 in head ( $4\frac{1}{3}$  in *macdonaldi*). The body is also less elongate than in *macdonaldi*.

In var. *pleuriticus* there is almost always a very distinct red lateral band, and the lower fins are more or less red.

f. *Salmo mykiss spilurus* (Cope). The Trout of the Rio Grande. (Plate III, Figs. 7 and 8.)

Abounding in all its tributaries and extending southward in the mountains to northern Chihuahua. This form is apparently wholly identical with var. *pleuriticus* except that in the specimens examined the scales are less crowded forward, so that the number in a lengthwise series is less. I count 155 to 160 in Rio Grande specimens; 185 to 190 in those from the Colorado. From the trout of the Great Basin (*virginalis*), *spilurus* differs chiefly in the arrangement of its spots.

g. *Salmo mykiss virginalis* (Girard). (*Salmo utah* Suckley.) The Trout of Utah Lake. (Plate III, Fig. 9.)

The trout of the Great Basin are profusely and not very coarsely spotted, the spots being numerous anteriorly as well as posteriorly, confined to the back rather than to the tail. In several examined, the scales are a little larger than in any of the other forms, 140 to 150 in a lengthwise series, the scales on the anterior part of



FIG. 4. RED-THROATED TROUT (*Salmo mykiss lewisi*). Young. (See page 14.)



FIG. 5. LAKE TAHOE TROUT (*Salmo mykiss henshawi*). (See page 14.)



FIG. 6. COLORADO RIVER TROUT (*Salmo mykiss pleuriticus*). (See page 14.)



the body being less crowded than in *spilurus* and *stomias*. In other respects *virginalis* scarcely differs from *clarki*.

The large fishes from Utah Lake are very pale in color, the dark spots few and small, much as in var. *macdonaldi*, but fewer, and more on the back. This pale coloration is characteristic of lake and sea trout in general. It is doubtless partly due to the alkaline character of the waters of Utah Lake.

**h. *Salmo mykiss stomias* (Cope). (Plate I, Fig. 2.)**

Arkansas and Platte Rivers. A small trout, with very large black spots and small scales. It closely approaches *lewisi* and *spilurus*. The black spots are always larger than in any of these, and mostly gathered on the tail.

**i. *Salmo mykiss macdonaldi* Jordan and Evermann. Yellow-finned Trout. In Twin Lakes. (Plate I, Fig. 1.)**

The most strongly marked of these varieties so far as color and general appearance are concerned. The head is long and the opercles longer than in most of the others. Probably an early off-shoot, perhaps inhabiting these lakes prior to the advent of var. *stomias* in the same region. The nearest relative is *pleuriticus*, from which I think it is descended.

**k. *Salmo mykiss bouvieri* (Bendire). (Plate IV, Fig. 10.)**

In Waha Lake, in Washington, a mountain lake without outlet; a peculiar form, with short, blunt head, large eye, moderate (160) scales, and the spots confined to the posterior half of the body. This form seems to be an off-shoot from *clarki*.

The following table was taken from a number of specimens of partly grown trout, most of them from 8 inches to a foot in length (those from Utah Lake, Henry Lake, and Riddle Lake being larger). In the size of fins, number of gill-rakers, dentition, etc., no differences of any importance have been noticed.

	Head in length.	Depth in length.	Eye in head.	Maxillary in head.	Scales.	Spots.
Trapper's Lake ( <i>spilurus</i> ).....	4 $\frac{2}{3}$	4 $\frac{2}{3}$	5	1 $\frac{5}{8}$	189.....	Large, close, and chiefly posterior.
Gunnison River ( <i>pleuriticus</i> ).....	4 $\frac{1}{3}$	4 $\frac{1}{3}$	5	2	188 (125 pores)	Large; chiefly posterior; a few on head.
Rio Florida ( <i>pleuriticus</i> ).....	4 $\frac{1}{6}$	4 $\frac{2}{6}$	4 $\frac{2}{3}$	2	185.....	Same; anterior spots smaller.
Rio Grande ( <i>spilurus</i> ).....	4	4	5 $\frac{1}{2}$	1 $\frac{3}{10}$	155 (115 pores)	Large; chiefly on tail.
Rio Grande ( <i>spilurus</i> ).....	4 $\frac{1}{4}$	3 $\frac{5}{6}$	5	2	160.....	Same.
Wallawalla ( <i>clarki</i> ).....	3 $\frac{5}{6}$	4 $\frac{1}{6}$	4 $\frac{1}{2}$	1 $\frac{1}{2}$	177.....	Rather large; scattered almost equally.
Henry's Lake, Idaho ( <i>clarki</i> ).....	4 $\frac{1}{8}$	3 $\frac{5}{6}$	5	1 $\frac{1}{2}$	178.....	Small; very closely set, especially behind.
Riddle Lake, Wyoming ( <i>lewisi</i> )...	4 $\frac{1}{8}$	4 $\frac{1}{8}$	5	1 $\frac{1}{2}$	170.....	Rather large; not close set; more numerous behind, but not confined.
Utah Lake ( <i>virginalis</i> ).....	3 $\frac{3}{4}$	4 $\frac{1}{4}$	5	1 $\frac{3}{8}$	148 (150 pores)	Small; mostly confined to back; few on tail.
Provo River ( <i>virginalis</i> ).....	3 $\frac{5}{6}$	4 $\frac{1}{2}$	5	2	145 (121 pores)	Rather large; scattered equally.
Provo River ( <i>virginalis</i> ).....	4	4 $\frac{1}{2}$	5	2	141.....	Same.
Bear Creek, near Denver ( <i>stomias</i> )..	4 $\frac{1}{2}$	4 $\frac{3}{4}$	4 $\frac{1}{2}$	2	180.....	Large; largest on tail.
Twin Lakes ( <i>stomias</i> ).....	4 $\frac{1}{6}$	4 $\frac{2}{6}$	4 $\frac{1}{2}$	2	193 (140 pores)	Very large; well defined; largest on tail.
Twin Lakes ( <i>macdonaldi</i> ).....	4 $\frac{1}{10}$	4 $\frac{1}{6}$	5 $\frac{1}{2}$	2	184.....	Very small; smaller than nostril; most numerous behind.
Waha Lake ( <i>bouvieri</i> ).....	4	4 $\frac{3}{4}$	4 $\frac{1}{2}$	1 $\frac{5}{8}$	183.....	Very small; most numerous behind.
Eagle River ( <i>pleuriticus</i> ).....	4 $\frac{1}{10}$	3 $\frac{5}{6}$	4 $\frac{1}{2}$	1 $\frac{5}{8}$	160.....	Large; all on the tail.
					175.....	Very small; most numerous behind.

Besides the native trout, *macdonaldi* and *stomias*, the following trout have been introduced into the Twin Lakes.

**Salvelinus fontinalis** (Mitchill).

This species does well, growing faster than the native trout. It seems to prefer the colder waters of the upper lake.

**Salmo irideus** Gibbons.

This species is doing well, and is already becoming common.

**Salmo salar** sebago (Girard).

The land-locked salmon was introduced about 1885. They grow very slowly in the Twin Lakes, and rarely exceed one-half pound. They are occasionally taken.

## ARKANSAS RIVER, BELOW THE CAÑON.

1. **Ameiurus melas** (Rafinesque). P.

Rather scarce.

2. **Catostomus teres** (sucklii Girard). A., P.

Everywhere common.

3. **Campostoma anomalum** (Rafinesque). A.

Scarce. *Campostoma aikenii* Cope, from Pueblo, is identical with *C. anomalum*.

4. **Pimephales promelas confertus** (Girard). A., P., C., F.

Very common in muddy shallows.

5. **Notropis scylla** (Cope). P.

In the river channel. Not common. This is the species recorded by Dr. Gilbert from Kansas as *Notropis deliciosus lineolatus*. *Notropis chlorus* (Jordan) is probably the same species. Agassiz's *lineolatus* may be this or some of the related species. The short description is insufficient to permit identification, and the name should not be used. The same remarks apply also to Rafinesque's name *microstomus*, which I have elsewhere used instead of *stramineus* and the still older name *deliciosus*. *Notropis phenacobius* Forbes is identical with *N. scylla*, as I am informed by Dr. Gilbert, who has examined Dr. Forbes's types. *N. scylla* is close to *N. deliciosus*, but stouter in body with a shorter, blunter, and deeper head. Its scales are larger, but those before the dorsal are smaller and more crowded. Mouth small with subequal jaws, the cleft somewhat oblique. Head  $3\frac{2}{3}$ – $4\frac{1}{4}$ ; depth  $4$ – $4\frac{1}{4}$ ; scales 31–33; 14–15 before dorsal; maxillary equal to eye,  $3\frac{1}{5}$ – $3\frac{1}{2}$  in head; snout 4. Pectoral nearly reaching ventral. Color pale, a dusky shade before dorsal and one on each side of the fin, as in *N. deliciosus*; some dark dots on side of snout; a faint dark lateral shade. In *N. deliciosus* the scales are 34–38, 12 before dorsal; eye, 3 in head; body and head more slender. Renewed comparison of specimens from White River, Indiana, with others from Rio Conchos in Texas, confirms my belief in the complete identity of *N. deliciosus* and *N. stramineus*.

6. **Notropis lutrensis** (Baird and Girard). P., F.

Very common at Pueblo; some specimens highly colored; bodies blue, fins crimson.

7. **Rhinichthys dulcis** (Girard). P.

Abundant and large in the river and in Grape Creek. Fins often red.

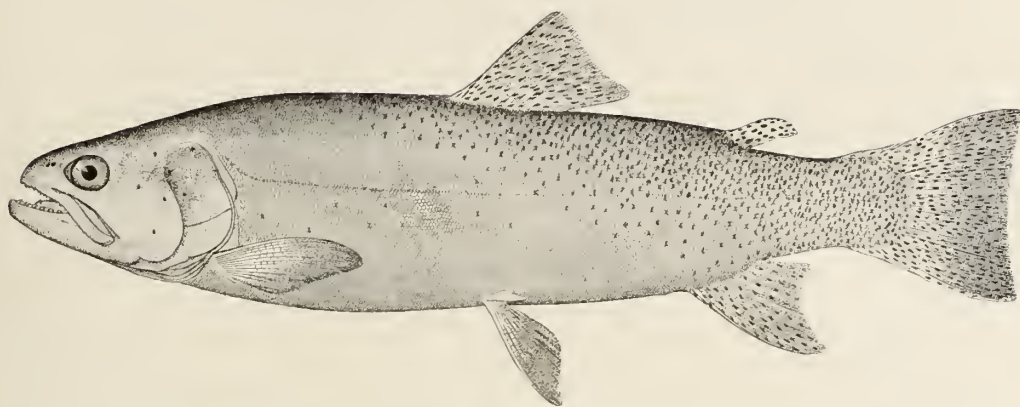


FIG. 7. RIO GRANDE TROUT (*Salmo mykiss spilurus*). Adult. (See page 14.)

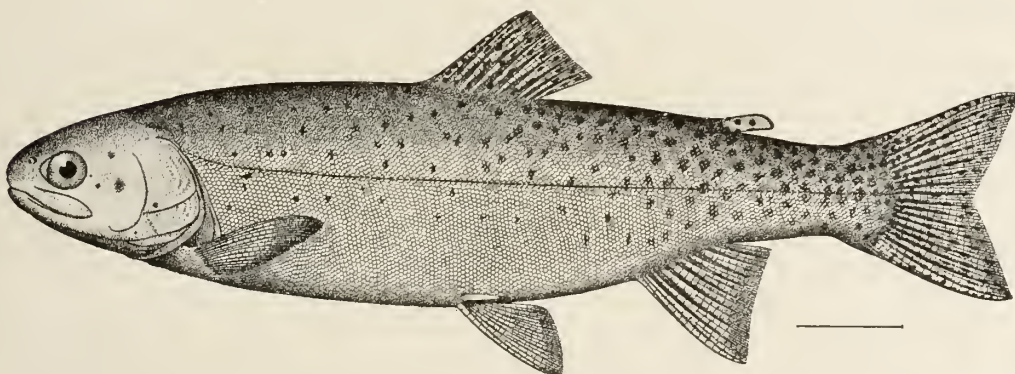


FIG. 8. RIO GRANDE TROUT (*Salmo mykiss spilurus*). Young. (See page 14.)

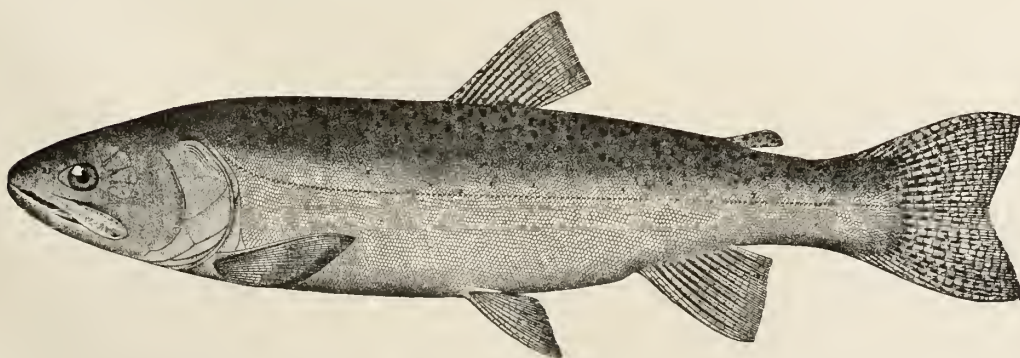


FIG. 9. UTAH LAKE TROUT (*Salmo mykiss virginalis*). (See page 14.)



8. *Platygobio physignathus* (Cope). A., F.

Very common, the most abundant species in the river. This species is a true *Platygobio*, not a *Couesius*. It differs from *P. gracilis* in having the head shorter, narrower, and blunter, less depressed above. Anterior profile forming a nearly even curve, which is everywhere convex. Head  $4\frac{2}{3}$  in length, depth  $4\frac{2}{3}$ , scales 6-48-5, 20 scales before dorsal, snout 3 in head; teeth with distinct grinding surface. In *P. gracilis* the broad head is concave in profile above the eye. *P. pallidus* Forbes may be a valid species, but from the description I can not tell it from the young of either of the others. Our specimens from St. Joseph, Mo., seem to be *P. gracilis*.

9. *Hybognathus nuchalis* Agassiz (var. *placita*). P.

Not rare in the river.

10. *Hybopsis tetranemus* Gilbert. P.

One specimen of this singular little fish. Barbels long, the second pair nearly as long as the eye. Some of the specimens from the Arkansas basin, recorded by Jordan & Gilbert as *Hybopsis aestivalis*, belong to the species.

11. *Fundulus zebrinus* Jordan & Gilbert. F., C.

Very common in brooks and the pond; not seen in the river.

12. *Lepomis cyanellus* (Rafinesque). C.

One found in the pond at Cañon City.

13. *Etheostoma cragini* Gilbert. C.

Very abundant in the pond at Cañon. Head naked; fins with brick-red shades; body with blue specks in life; body and fins profusely punctulate with black.

## C.—ARKANSAS RIVER AT WICHITA.

1. *Ameiurus melas* (Rafinesque).2. *Ictalurus punctatus* (Rafinesque).3. *Ictiobus bubalus* (Rafinesque).4. *Ictiobus difformis* (Cope).

Numerous specimens; the dorsal rays low, little longer than head and stout at base. Eye  $4\frac{1}{2}$  in head. Snout short, very blunt.

5. *Moxostoma duquesnei* (Le Sueur).

Head  $4\frac{2}{3}$  in length in one example, and head  $4\frac{1}{2}$  in another.

6. *Camptostoma anomalum* (Rafinesque).7. *Hybognathus nuchalis* Agassiz.

Numerous examples of the ordinary type.

8. *Pimephales promelas confertus* (Girard).

Scarcely if at all different from the common *promelas*.

9. *Pimephales notatus* (Rafinesque).10. *Cliola vigilax* Baird & Girard.11. *Notropis scylla* (Cope).

Abundant.

12. *Notropis cayuga* Meek.

Abundant. This is a widely diffused species, allied to *N. heterodon*, from which it is easily known at sight by the absence of black on the chin. Head,  $4\frac{1}{6}$  in length; depth,  $4\frac{1}{2}$ ; scales, 36; 14 before dorsal; lateral line wanting on some scales; mouth

very small, anterior, the maxillary not reaching to eye; eye large, equal to snout,  $3\frac{1}{2}$  in head; jaws, subequal; scales above, dark-edged, very sharply defined; a black stripe through snout and eye, with a dusky lateral shade and a small caudal spot. *Notropis fretensis* (Cope) may be this species, but the short description applies as well to *N. heterodon*. Some of the references to *heterodon* may belong to *N. cayuga*. Among the specimens taken by Dr. Gilbert and the writer in Rio Comal at New Braunfels, Tex., is one not mentioned in our paper (Proc. U. S. Nat. Mus., 1886, 23) closely resembling *N. cayuga*, but with the snout a little more blunt in profile; the scales, form, and coloration being the same. Another in Dr. Gilbert's collection (Long Lake, Ill., Harrison Garman) agrees fully with this one, but we are unable to decide whether the species they represent is different from *Notropis cayuga*.

13. *Notropis camurus* Jordan & Meek.

Very abundant.

14. *Notropis bubalinus* (Baird & Girard).

One example. More elongate than the species described, but if the variations in this species are the same as in the allied *lutrensis*, this has little significance. Head, 4 in length; depth,  $3\frac{1}{2}$ ; scales 36; 18 before dorsal. Closely related to *N. camurus*, but the dorsal without black blotch; scales a little smaller and less closely imbricated; head a little smaller.

15. *Notropis lutrensis* (Baird & Girard).

16. *Notropis umbratilis* (Girard).

17. *Notropis topeka* Gilbert.

A few specimens.

18. *Phenacobius mirabilis* (Girard).

Typical; scales, 49; their outlines obscure.

19. *Hybopsis storerianus* (Kirtland).

Abundant.

20. *Hybopsis tetranemus* Gilbert.

Seven examples.

21. *Dorosoma cepedianum* (Le Sueur).

22. *Labidesthes sicculus* Cope.

Common.

23. *Lepomis humilis* (Girard).

Common.

24. *Lepomis cyanellus* (Rafinesque).

25. *Lepomis megalotis* (Rafinesque).

Specimens small, and with a black spot on last ray of dorsal, as in Texan examples.

26. *Etheostoma caprodes* Rafinesque.

27. *Etheostoma lepidum* Baird & Girard.

A few; head scaleless.

## C.—RIO GRANDE BASIN.

The Rio Grande rises in the Saguache and Sangre de Cristo Mountains, at the head of San Luis Park. Its headwaters and its various tributaries are clear and cold, flowing through grassy mountain pastures, and being well stocked with trout. Of its upper tributaries, the following are all noted as trout streams, although the lower waters of all are consumed by the irrigating ditches: Saguache, San Luis, Madenia, Crestone, Piedras, Alamosa, La Jara, Conejos, Pinos, Ute, Sangre de Cristo, Trinchera, Costilla, Culebra, and Chama. In these streams thousands of trout are destroyed each year by the irrigating ditches, especially at the time of their downward migration in the fall. It is stated that nine-tenths of the trout in the San Luis Park have been thus destroyed. The streams of the northeastern part of the park (Madenia, Crestone) sink into the great sand dunes, the water rising from below as artesian springs, while the waters of the Saguache and the San Luis are lost in the alkaline San Luis lakes. Collections were made at the following points:

1. *Rio Grande* at Del Norte.—The Rio Grande here is a clear, full stream, with numerous trout, as well as chubs, minnows, and suckers. Temperature, 59°. The best trout fishing is found still higher up, about Wagon Wheel Gap. More trout are destroyed in ditches about Del Norte than anywhere else in Colorado. Species from Del Norte are marked D.

2. *Rio Grande* at Alamosa.—The stream here is quiet, with a bottom of adobe. The water is clear and rather cold (62°). In summer the stream is reduced to the seepage of irrigating ditches. In the deeper parts are multitudes of suckers and chubs. Species from Alamosa are marked A.

3. *Rio Conejos* at McIntyre's Ranch, about 15 miles south of Alamosa.—The clear stream is here 10 to 20 feet wide and 2 inches to 6 feet deep. The bottom is gravelly; the temperature 65°. Species taken here are marked C.

4. *Rio Chama* at Chama.—A clear, cold mountain stream, among those in southern Colorado best suited for trout.

5. *San Luis Lakes*.—Some 20 miles northeast of Alamosa there is a large depression in the plain. Into this flow several trout streams, the chief of these being the Saguache, San Luis, Madenia, and Crestone. The lower parts of this depression are occupied by the San Luis Lakes, but in ordinary summers none of these streams reach the lakes, the water either sinking into the sand or else being used in irrigation. The lakes are some six in number, ranging from 50 rods to 1 mile in length, filling one after another from the rains and from the soakage of the streams. They are connected by a broad ill-defined channel, usually dry, which extends to the Rio Grande, below Alamosa. The lakes are all strongly alkaline. The two examined were strongly impregnated with soda, and without fishes or any other animals. The uppermost is said to be less alkaline, but evidently all are worthless for fishes.

## FISHES OF THE RIO GRANDE.

1. *Pantosteus plebeius* (Baird & Girard) D., G., A.; *Catostomus guzmaniensis* Girard; (*Pantosteus jarrovi* Cope & Yarrow; not *Minomus jarrovi* Cope).

Very abundant everywhere, especially in the deeper places and eddies, reaching a length of about a foot.

This is the species well figured by Cope and Yarrow under the name of *Pantosteus*

*jarrovi*, from the Rio Grande. The original *Minomus jarrovi* of Cope is from Provo, Utah, and is the species described by Girard as *Acomus generosus*, and by Cope as *Minomus platyrhynchus*. The original *Catostomus guzmaniensis* and the original *Catostomus plebeius* are from Lake Guzman, in Chihuahua, a lake without outlet, but belonging to the Rio Grande Basin.

Among the many specimens of *Pantosteus* examined by us we recognize three species, each one, so far as our own collections show, confined to a distinct river basin. The following analysis shows the principal characters of each of these:

- a. Scales moderate, 80 to 90 in the lateral line, 28 to 30 in a cross series between dorsal and ventral; mouth and lips of moderate size; dorsal rays usually 9.
  - b. Head comparatively short and small,  $4\frac{1}{2}$  to 5 in length of body; body slender, the depth 5 to  $5\frac{3}{8}$  in length; 45 to 50 scales before the dorsal; scales 15-18-14. Great Basin of Utah (*generosus* Girard=*platyrhynchus* Cope=*jarrovi* Cope) ..... *Generosus*.
  - bb. Head comparatively large,  $4\frac{3}{8}$  to  $4\frac{3}{4}$  in body; body more robust, the depth  $4\frac{3}{8}$ ; dorsal fin a little higher and pectoral a little longer. Rio Grande Basin and Lakes of Chihuahua (*plebeius* Baird and Girard=? *guzmaniensis* Girard=*jarrovi* Yarrow, not of Cope) ..... *Plebeius*.
- aa. Scales very small, 95 to 103 in the lateral line; 20 to 33 in a cross series between dorsal and ventral; mouth large, with very full lips; head rather short,  $4\frac{3}{8}$  to  $4\frac{3}{4}$  in length; tail very slender, the caudal long; 50 scales before dorsal; depth of body about 5 in length; scales 16-96 to 99-14. Basin of Colorado River (*delphinus* Cope=? *bardus* Cope=*virescens* Cope=*guzmaniensis* Jordan Cat. Fish. N. A., 1885, probably not of Girard) ..... *Delphinus*.

These three species are certainly distinct from each other and are very common, each in its respective hydrographic basin. If other species exist they are unknown to us.

## 2. *Leuciscus pulcher* (Girard). C., A., D.

(*Gila pulchella* Baird & Girard, Proc. Ae. Nat. Sci. Phila., 1854, 29, Rio Mimbres, Lake Guzman, Chihuahua, not *Leuciscus pulchellus* Storer; *Tigoma pulchra* Girard, Proc. Ae. Nat. Phila., 1856, 207, Chihuahua R.; *Clinostomus pandora* Cope, Hayden's Geol. Survey Montana for 1871, 475, 1872, Rio Grande in New Mexico.)

The chub or "Pescadito" is everywhere abundant, reaching a length of 6 or 8 inches. It is found in eddies and deep places with the preceding species. The synonymy of the species is given above. There seems to be little room for doubting the identity of *pulehella*, *pulehra*, and *pandora*, and no other species of this genus has yet been authentically recorded from the basin of the Rio Grande. The earliest name, *pulehellus*, is preoccupied in the genus *Leuciscus*.

Head  $4\frac{1}{2}$  in length; depth  $4\frac{2}{5}$ ; scales 15-67-10; axils red in the male. Teeth often irregular in number, sometimes 1, 4-4, 1.

## NOTE ON THE GENERIC NAME LEUCISCUS.

For a number of years American writers have referred our species with the teeth 1 or 2, 4-5, 2, and with hooked tips, to the genus *Squalius* Bonaparte.

Comparing the American species with the European representatives of this type, we find that while there is a general agreement in technical characters the European species have much larger and looser scales, and the scales have the radiating striae more prominent. The European species have in fact the same squamation as our genus *Notemigonus*. The teeth in *Squalius* proper are 2, 5-5, 2, in all species, so far as examined.

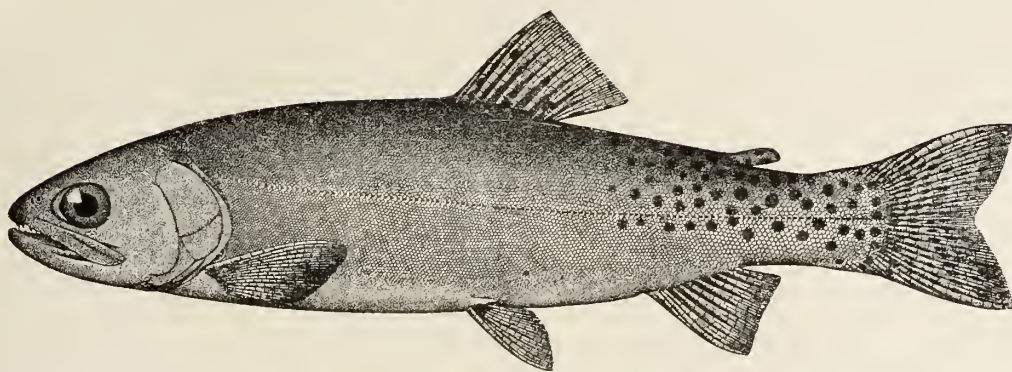


FIG. 10. WAHA LAKE TROUT (*Salmo mykiss bouvieri*). (See page 15.)

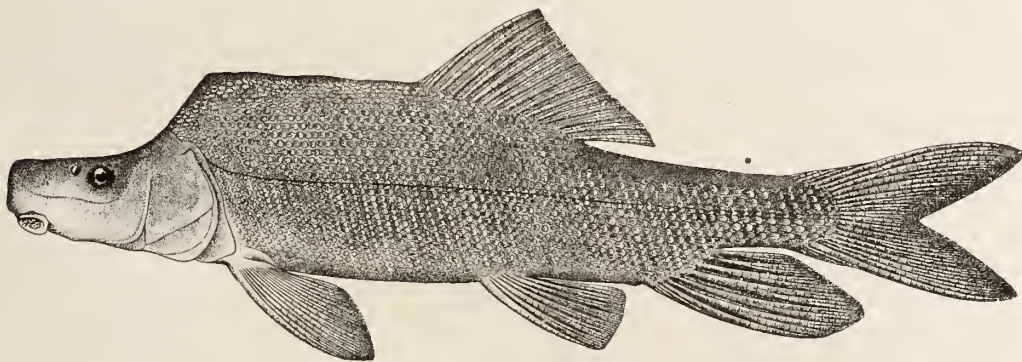


FIG. 11. HUMP-BACK SUCKER (*Xyrauchen cypho*). (See page 26.)



There is, however, in Europe a subgeneric group called *Telestes* by Bonaparte, which approaches much more nearly to the American forms. The scales in *Telestes* are small, ranging from 60 to 80, and the teeth are 2, 4-5, 2. I know of no character by which the American species called *Tigoma* can be set off from *Telestes*, nor does any definite character exist by which *Siboma*, *Cheonda*, and *Clinostomus* can be separated from *Tigoma*. *Protoporus* Cope is apparently also based on a young *Tigoma*.

It is, however, true that European writers generally hold the distinctions between *Telestes* and *Squalius* as of very slight value, and the figures and specimens accessible to us seem to show a pretty regular gradation from one type to the other. Nevertheless, no American species of this type is a near ally to *Squalius cephalus*, and none have the pharyngeal bones equally armed with 5 teeth in the main row so far as we know. For the present we may unite *Tigoma* with *Telestes* and *Squalius* as forming a single genus.

It seems to me, however, that the name *Leuciscus* should be used instead of *Squalius* for the group typified by *Leuciscus cephalus* and *L. leuciscus*.

The generic name *Leuciscus* was first applied by Cuvier in 1817 to a group of Cyprinoids about corresponding to the *Leuciscinae* of present classifications. Five species are mentioned especially by Cuvier in his text, and several others are referred to incidentally in a foot note. Among the five mentioned in the text the type of this genus *Leuciscus* must be chosen.

These species are *Cyprinus dobula* L., *C. rutilus* L., *C. leuciscus* L., *C. alburnus* L., and *C. phoxinus* L.

In the Ichthyologia Ohiensis, 1820, Rafinesque adds numerous American species to the genus *Leuciscus*, proposing for them the new generic names of *Minnilus*, *Luxilus*, *Plargyrus*, and *Pinephales*. At the same time he divides the European species into five genera, *Dobula*, *Rutilus*, *Leuciscus*, *Alburnus*, and *Phoxinus*, the names and order corresponding to the order of the species as given by Cuvier. These genera are each briefly defined, but no typical species is mentioned, except in one case, a page or two later, where he speaks of *Cyprinus rutilus* L. as the type of *Rutilus*.

By Rafinesque's arrangement *Cyprinus rutilus* is made the type of *Rutilus* and *C. leuciscus* that of the restricted genus *Leuciscus*.

Later, Agassiz, not noticing the work of Rafinesque, similarly restricted *Leuciscus* to the species having two rows of teeth, *Rutilus* having but one.

Still later, Bonaparte made *Cyprinus leuciscus* the type of his restricted genus *Leuciscus*, and added *Scardinus*, *Squalius*, and *Telestes* for other species, the group called *Squalius* practically corresponding to the *Dobula* of Rafinesque, which is doubtless identical also with Rafinesque's *Leuciscus*.

At about the same time Heckel made more thorough investigations of the characters of these fishes than any of his predecessors had done. In his arrangement, *Cypr. dobula* and *Cypr. leuciscus* were referred together to *Squalius*, while the name *Leuciscus* was transferred to *L. rutilus*. The system of Heckel has been generally followed by later writers, although by Günther and others all these groups have been regarded as simple sections or subgenera under *Leuciscus*.

It seems evident that *Cyprinus leuciscus* must stand as the type of *Leuciscus*, and that the generic name of *Cypr. rutilus* must be *Rutilus*.

The genera concerned would then be:

1. *Leuciscus* (Cuvier), Rafinesque, Agassiz, and Bonaparte=*Dobula* Rafinesque=

*Squalius* Bonaparte, (probably including *Telestes* Bonaparte=*Tigoma*, *Cheouda*, *Siboma*, and *Clinostomus* Girard and *Protoporus* Cope).

2. *Rutilus* Rafinesque (= *Leuciscus* Heckel, Günther = *Leucos* Heckel = *Pigus* Bonaparte; possibly should include *Myloleucus* Cope) species with the teeth 4-5 instead of 5-6 or 5-5, as in *Rutilus*.)

3. *Alburnus* Rafinesque = *Alburnus* Heckel.

4. *Phoxinus* Rafinesque = *Phoxinus* Agassiz.

For the present, at least, until better definitions can be given, we may refer the American species to the genus *Leuciscus* in which they form a subordinate group (*Tigoma* or *Telestes*) distinguished by the smaller number of teeth and the generally smaller scales.

3. *Rhinichthys dulcis* (Girard), A., D., C. (*Rhinichthys transmontanus* Cope.)

Very common. We are unable to distinguish our specimens from the Rio Grande, from those taken by us in the Arkansas, Platte, and Yellowstone. As the types of *Rhinichthys transmontanus* are from New Mexico, we regard the latter species as a synonym of *R. dulcis*. *Rhinichthys maxillosus* Cope, originally described from Kansas, is the same as *R. dulcis*.

4. *Salmo mykiss* Walbaum, D., C. (Var. *spilurus* Cope.)

Abundant in the upper Rio Grande, and in all tributary streams down to the level of the valley.

The Rio Grande trout have the dark spots rather large and more or less confined to the dorsal and caudal fins and the region between them, though often, especially in the young, extending on the head. They reach a fair size, a pound or two in weight, but are doubtless not as large as the trout of the Upper Colorado. The Rio Grande trout was first described as a distinct species by Professor Cope under the name of *Salmo spilurus*. The types of this nominal species came from the Sangre de Cristo.

#### D.—COLORADO BASIN.

The Colorado River is formed by the union of two large rivers, Green River and Grand River. Both of these have their source in the mountain streams of the western slope of the Rockies, and are very clear and cold in their upper courses. Lower down they become gradually turbid and yellow and finally the Colorado becomes one of our muddiest streams. The headwaters everywhere are full of trout, and all the tributary lakes, many of which exist in northwestern Colorado, are especially well stocked. The fish fauna of this great river is very scanty. In the highlands the trout is accompanied by *Agosia* only. Lower down the "Blob" appears; still lower the snekers, four species in all in the upper waters, and with them the Round-tail (*Gila robusta*) and the "White salmon" (*Ptychocheilus*). This is the largest and best food-fish of the Lower Colorado and the largest of the carp family in America. The Bony-tail (*Gila elegans*) is found still lower down, while in Arizona the fauna is further increased by the addition of three or four more snekers and of species of *Leuciscus*, *Meda*, and other genera of chubs and minnows. Collections were made by us at the following localities:

1. *Grand River*, at Glenwood Springs, Colo.—The Grand River rises in the middle of northern Colorado flowing southwestward through deep gorges. Glenwood Springs lies at the foot of its deepest cañon. The water is here yellow and muddy, but the

clay comes chiefly from the placer mining above. The stream at Glenwood is broad and swift, while the bottom is full of large boulders so that it can not be easily seined. Two large suckers (*C. latipinnis*) were taken here. It is said that these suckers in winter come here for the warmth of the Hot Springs.

2. *Sweetwater Lakes* in Eagle County, Colo.—Some 25 miles above Glenwood are the Sweetwater Lakes, noted for trout. Several specimens of these trout were procured from fishermen.

3. *Trapper's Lake*, in Garfield County, Colo.—This is a noted locality for trout fishing, in the mountains some 40 to 50 miles north of Glenwood. Several fine examples of these trout were procured from anglers.

4. *Eagle River*.—This is a very clear, cold stream, flowing into Grand River from the east. It is very well stocked with trout, large numbers being taken with the fly. At Gypsum, where our collections were made, the river is about 20 feet wide and 2 to 4 feet deep. The bottom is rather smooth, but the water is too cold for seining. At this point, besides trout, are found *Cottus*, *Pantosteus*, and *Agosia*, the *Cottus* being excessively abundant.

5. *Roaring Fork of Grand River*.—The Roaring Fork rises in the mountains, above Aspen, and enters the Grand from the south near Glenwood. It is very clear, but not very cold (temperature 67°). Its lower course is swift, its channel filled with boulders washed from the great moraine through which it breaks its way. It is about 2 rods wide and 2 to 4 feet deep. Seining is impossible. Suckers (*C. latipinnis*) and blob were taken here. The stream is said to be well stocked with trout.

6. *Cañon Creek*.—This is a small stream flowing into the Grand below Glenwood. Some trout from this stream were secured from a fisherman.

7. *Gunnison River*, at Gunnison, Col.—The Gunnison is the chief tributary of the Grand, entering it from the south at Grand Junction. The Gunnison rises on the west slope of the Main Divide. Its upper course is largely quiet, flowing through mountain pastures with willow-covered banks. Below Gunnison it cuts its way through the Black Cañon, one of the deepest in Colorado. Above the cañon the river is very clear and full of trout, but one other species (*Agosia*) going with it. Below the cañon the water is warmer and less clear; trout are scarce and suckers and round-tails become abundant. The river at Gunnison is swift, with gravelly or rocky bottom; some 3 rods wide and 2 to 4 feet deep. In the cañon are many rapids and pools 6 to 20 feet deep.

8. *Tomichi Creek*, near Gunnison.—This is a clear stream about 6 feet wide and 2 to 20 inches deep, flowing in many windings with little current and with grassy banks covered with small bushes. It is not so cold as the river (about 72°); its bottom has a good deal of black muck. White ranunculus and other water-weeds abound and the stream much resembles a New England trout brook.

The Eastern brook trout (*Salvelinus fontinalis*) was successfully introduced into Tomichi Creek about 1883. Both this and the native trout were abundant in the upper course of the stream, but at Gunnison the waters are crowded with *Agosia yarrowi* and have no other fish.

9. *Rio Cimarron*.—This stream flows into the Gunnison in the Black Cañon. In the pastures above Cimarron station (2 miles above its mouth) it is a good trout stream. At Cimarron the stream is clear and swift with a bottom of gravel and small boulders

about 12 feet wide and 1 to 4 feet deep. Temperature 68°. No fishes were obtained with the net.

10. *Gunnison River*, at Delta, Colo.—At Delta, some distance below the Black Cañon, the Gunnison is a large stream 3 to 4 rods wide and 2 to 5 deep, the waters clear and of a summer temperature of about 72°. Its current is swift, and in its broad channel are many islands. The bottom is gravelly or sandy, and in still places occasionally muddy. The fishes here are the "Razor-back" or "Hump-back sucker" (*Xyrauchen cypho*), the "Flannel-mouth sucker" (*Catostomus latipinnis*), the "Blue-head sucker" (*Panosteus delphinus*), the "Bony-tail" (*Gila elegans*), the "Round-tail" (*Gila robusta*), the "White Salmon" (*Ptychocheilus lucius*), the "Bull-head" (*Cottus bairdi punctulatus*) and the minnow (*Agosia yarrowi*).

11. *Uncompahgre River*.—This stream rises in the wild Uncompahgre Pass, above Ouray. In its upper course, it has few or no fishes, for it flows through wild and deep ravines with many cascades. Besides this, it has iron springs among its feeders, and trout seldom or never live in iron waters. Above Ouray, are some hot springs, and at Ouray stamp-mills render the water impure. Below Ouray are some trout, but probably not many.

Between Ouray and Montrose, the stream leaves the mountains, and from Montrose to its mouth at Delta, it is very sluggish and its waters are largely drawn off by the irrigating ditches. The plain is largely alkaline, and the banks of the stream are lined with greasewood (*Sarcobatus vermiculatus*), the sure indication of an alkaline soil. At Delta the only water left is from the seepage of ditches. This is grayish yellow, and forms a succession of pools with bottom of gravel or mud, some of them 5 or 6 feet deep. Temperature 78°. The water is full of fishes of the species enumerated above as found in the Gunnison. *Gila elegans*, *Agosia*, and *Cottus* were not seen in the Uncompahgre. On the other hand, a single specimen of what seems to be a new species of *Xyrauchen* was taken in the little pond close to the station at Delta.

12. *Green River*, at Blake City (Green River Station), Utah.—At this point the river flows through a barren desert, its course largely bounded by high cliffs. Its waters are yellow, and except on certain rocky shallows deep and sluggish. At low water the river is about 500 feet wide and 3 to 8 feet deep. In August the water was moderately clear, but at the time of the spring floods it becomes a paste of red mud. We seined the stream along the west side from the railroad bridge to the foot of the shallows about one-fourth mile below. *Xyrauchen cypho* is very abundant, reaching a weight of 10 pounds, and is a good food-fish. *Catostomus latipinnis* reaches 3 to 5 pounds. Besides these we obtained *Gila elegans*, a small fish regarded as worthless because full of bones. The trout do not descend Green River much if any below the boundary of Wyoming Territory.

13. *Price River* flows into the Green River from the west. It rises near the summit of the Wahsatch range. It soon becomes gray and muddy and when it strikes the desert at the eastern foot of the mountains its waters are all used for irrigation. Although a long river, its waters are nearly all lost in summer, and it is worthless for fish. It is said that trout occur in some ponds on the eastern slope of the Wahsatch.

14. *San Juan River*.—The San Juan is one of the chief tributaries of the Colorado, having its source in a considerable number of large, clear mountain streams, which head in the mountains of southwestern Colorado (Sierra San Juan, etc.), to the west of

the Main Divide. All these streams are well stocked with trout, their fauna being precisely like that of the Gunnison.

The lower San Juan enters the desert country and receives large numbers of "sand arroyos," dry beds flooded with mud after a rain. The water becomes warm, thick, and yellow, although all the upper sources of the river are clear and cold.

It is thought that the lower San Juan and the Colorado would be well suited for the growth of the larger eat-fishes as *Leptops olivaris*, *Ameiurus nigricans*, and perhaps *Ictalurus punctatus*. It would be well to make a plant of these at Green River Station, and one on the San Juan at Arboles.

15. *Rio de las Animas Perdidas*.—The Animas River is the largest tributary of the San Juan. It rises in the mountains above Silverton. Above its cañon of "Lost Souls," it is clear, shallow, and swift, flowing through an open cañon with a bottom of rocks. In its upper course it is said to be without fish, one of its principal tributaries, Mineral Creek, rising in Red Mountain and Uncompahgre Pass, being highly charged with salts of iron.

In the deep and narrow "Cañon de las Animas Perdidas" are many very deep pools, said to be full of trout. Below the cañon is "Hermosa Park," in which, for some 15 miles, the river flows over sandy bottom, with many deep holes and slight current. In these holes are many trout, and with them *Pantosteus delphinus*, *Agosia yarrowi*, and *Cottus bairdi punctulatus*.

At Animas City, above Durango, the stream enters a stony mesa, a glacial moraine, which, by its dam, has formerly made a lake of Hermosa Park. From this point, for miles below, the bottom is so covered with boulders that seining is impossible. At Durango the river is 2 to 3 rods wide and 2 to 4 feet deep; in the deeper holes, 6 to 8. The temperature is about 68°. The stream was seined at various places from Animas City to a point about 5 miles above Durango.

At Durango it is said that the larger snekers (*X. cypho*, *C. latipinnis*) and the "White salmon" (*Ptychocheilus*) ascend the river in the spring, going back to deep water after spawning in the summer.

16. *Leitner's Creek*, at Durango.—This is a little stream entering the Animas opposite Durango. In summer it is 2 to 3 feet wide, shallow, clear, and warm (72°) with sandy bottom. It contains *Cottus bairdi punctulatus* and *Agosia yarrowi*. Higher up its deeper pools are said to contain small trout.

17. *Rio Florida*.—This is a clear, cold stream, flowing into the Animas below Durango. It was seined at several points above the bridge about 8 miles east of Durango and north of Florida Station. It flows through a wooded valley over round boulders and with few deep places. Trout are abundant; also *Pantosteus delphinus*, *Agosia yarrowi*, and *Cottus bairdi punctulatus*. The last-named species lurks under every stone in the river.

18. *La Plata River*.—West of the Animas River is the Rio la Plata. It rises in the mountains above Fort Lewis, but the water mostly sinks in the sand and gravel below the fort. There are some trout here, but it is said that the stream contains too much iron to be well adapted for fish. It was not visited by us.

19. *Rio de los Pinos* (seen at Ignacio), the next river east of Rio Florida, is a clear, swift stream, with gravelly bottom, 2 rods wide and 1 to 3 feet deep. It runs through a broad valley which may become valuable for agriculture. I am told that Patrick

Brothers have a trout hatchery further up the river at Los Pinos. Like the Animas, this is an excellent trout stream.

20. *Ignacio Lakes*.—Near Los Pinos River are the San Ignacio Lakes, one of 60 acres, one of 40 acres, at 8,000 feet elevation. They are fed by springs and have no outlet. They have no fishes but are said to be "full of dog-fish (*Amblystoma*?) which devour the young trout which have been several times placed in the lakes." We were unable to verify this statement which was made by a citizen of Durango.

21. *Rio de las Piedras*, said to be the best trout stream in the San Juan basin, is similar to Los Pinos, but smaller.

22. *Rio Navajo*, which flows into the San Juan near Juanita, is also similar; a clear stream with gravelly bottom and wooded banks.

23. *Rio San Juan*, which receives the waters of all these, is, when crossed by the railroad at Arboles, about the size of Los Pinos at Ignacio. Its water is warm and not quite clear; the bottom of gravel and stones. About Pagosa Springs, above Arboles, it is a trout stream. Below Arboles it becomes very yellow, and at last it bears a volume of very muddy water into the Colorado.

#### FISHES OF THE UPPER COLORADO BASIN.

##### 1. *Catostomus latipinnis* (Baird & Girard). *Flannel-mouth Sucker*.

Very common in the Grand River at Glenwood Springs, in the Gunnison and Uncompahgre at Delta, and in Green River. It reaches a length of  $1\frac{1}{2}$  to 2 feet and a weight of 3 to 5 pounds. Dorsal rays usually 11, sometimes 12 or even 13. Caudal peduncle slender, and the fins all high; these characters especially marked in old males. Large specimens, in life blackish, olive above, abruptly paler below; sides bright creamy orange, deepest on the tail; snout and cheeks pale orange; belly pure white; lower fins all more or less orange; upper fins dusky olive, tipped with orange; pectoral dusky, orange above, creamy below; axil blackish; lips very thick and large. Female specimens have the same color, the only difference being that the male has the anal and lower lobe of caudal tuberculate. Stomach full of *confervæ* and other vegetation.

*Catostomus discobolus* Cope, from Green River in Wyoming, is probably based on the young of *Catostomus latipinnis*. The fishes from Idaho, formerly recorded by me as *Catostomus discobolus*, are probably different.

##### 2. *Xyrauchen cypho* (Lockington). *Razor-back Sucker*; *Hump-back Sucker*. (Plate IV, Fig. 11.)

This remarkable fish is very abundant in the river channels of the Colorado Basin. It reaches a weight of 8 to 10 pounds, and is largely used for food. Specimens were taken by us at Delta, both in the Gunnison and the Uncompahgre, and in Green River.

Specimens of 8 inches have the depth equal to length of head,  $3\frac{3}{4}$  in length. Scales 13-72, 73, or 74-13; D., 14. First dorsal ray,  $1\frac{1}{2}$  in head; base of the fin,  $1\frac{1}{4}$ . Least depth of caudal peduncle, 3 in head;  $1\frac{1}{2}$  in distance from last anal to first caudal ray. Nuchal crest much elevated, commencing by a prominence close to the nape, and with no scales before it; nuchal crest nearly or quite naked on the median line.

##### 3. *Xyrauchen uncompahgre* Jordan & Evermann, sp. nov. (Plate V, Fig. 12.)

A single young specimen of *Xyrauchen*, about 7 inches long, taken in the Uncompahgre River, close to the railway station at Delta, differs much from the others, and probably represents a distinct species of the same singular genus.

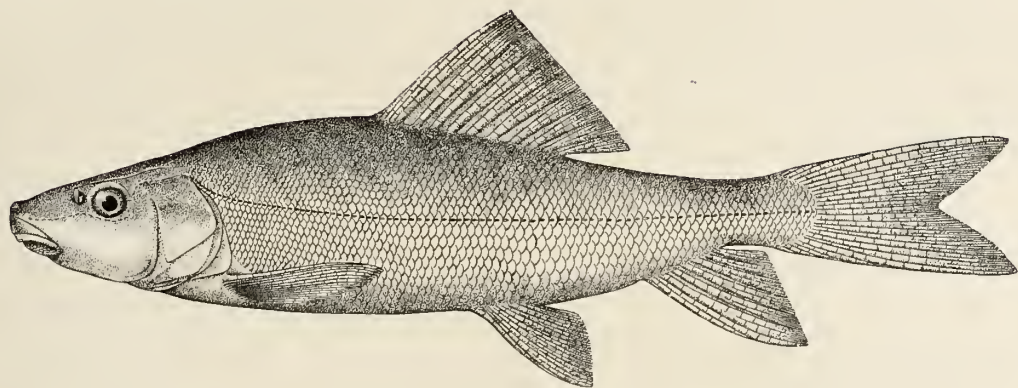


FIG. 12. UNCOMPAHGRE SUCKER (*Xyrauchen uncompahgre*). (See page 26.)

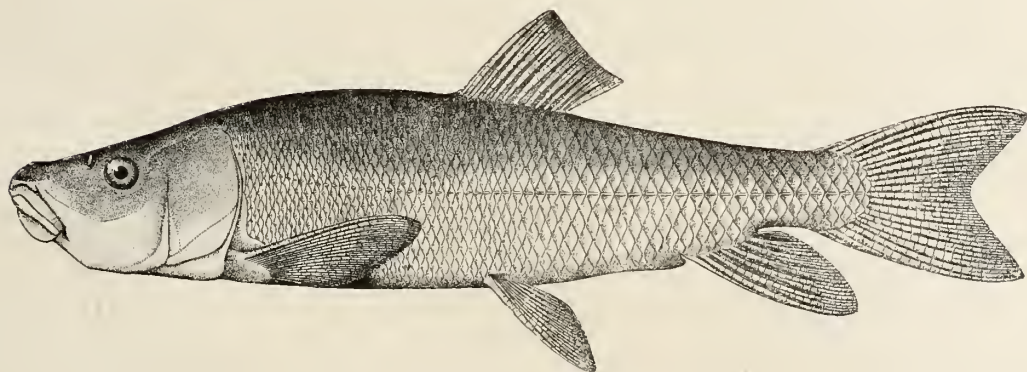


FIG. 13. THE "SUCKER" (*Chasmistes liorus*). (See page 31.)



Head, 4; depth,  $4\frac{1}{3}$ ; D. 12; A. 7. Scales 16-80 to 83-13.

Body more elongate than in *X. cypho* of the same size, the form resembling that of a *Gila*; head flattish above, narrower and less depressed than in *X. cypho*, the snout sharper than in *X. cypho*, projecting considerably beyond the small mouth; lips rather small, but rather larger and more coarsely tuberculate than in *X. cypho*, the upper with three rows of papillæ, the lower deeply incised.

Nuchal hump, formed by the expanded interneurals, much lower than in *X. cypho*, but forming a sharp keel. This does not extend forward to the nape, there being about thirteen scales before it. Surface of nuchal keel scaly.

Eye,  $5\frac{1}{2}$  in head; snout,  $2\frac{1}{4}$ ; interorbital space,  $2\frac{1}{3}$ . Scales smaller than in *X. cypho*, small anteriorly, growing larger backward; breast naked; caudal peduncle slender, much slenderer than in *X. cypho*, its least depth  $1\frac{1}{3}$  in its length and  $3\frac{2}{5}$  in head. Caudal fin large, deeply forked, a little longer than head. Dorsal lower than in *X. cypho*; the longest ray,  $1\frac{1}{2}$  in head; base of fin,  $1\frac{1}{4}$ . Pectoral,  $1\frac{1}{5}$  in head, not reaching ventrals; the latter to vent.

Color bluish above, pale below. Peritoneum black.

Type in the U. S. National Museum.

4. *Pantosteus delphinus* (Cope). *Blue-head Sucker*.

Common, especially near the mountains. Specimens taken in Eagle River, Gunnison River at Delta, Uncompahgre River, Rio de las Animas Perdidas, and Rio Florida. This species reaches a length of about a foot and is well characterized by its small scales and its large lips. Many die in the rivers after spawning.

In life, bluish, olive, or gray; lower fins dull orange; several round dashes of red along the lateral line, forming an interrupted red band. Scales 96 to 105.

5. *Gila robusta* (Baird & Girard.) *Round-tail*.

Generally common at the foot of the mountains; replaced by *Gila elegans* in the river channels. Found in the Uncompahgre, and in the Gunnison at Delta.

The species of *Gila* are very similar to each other and are probably reducible to three, *G. elegans*, *G. robusta*, and *G. seminuda*. The last-mentioned I have not seen.

Our specimens from the Gunnison evidently correspond to *Gila robusta*. *Gila grahami* B. & G. seems to be the same. I can not distinguish *Gila affinis* Abbott from *Gila robusta*. This species has been reported from the Kansas and the Platte, but the types doubtless came from Green River, as no recent collectors have found any species of this type anywhere except in the basin of the Colorado and Gila Rivers. *Gila gracilis* B. & G. is not evidently different from *G. robusta*. *Gila naerca* Cope, from Green River, Wyoming, is evidently the young of *Gila robusta*. Dr. Gilbert has reached independently similar conclusions as to the synonymy of these species.

*Gila robusta* reaches a length of more than a foot. It is full of small bones and is regarded as worthless for food. The males in life have the lower fins and lower side of the head red, and there is a vertical dash of red on the cheeks. Scales 79 to 82 in the lateral line, those above and below smaller.

6. *Gila elegans* Baird & Girard. *Bony-tail*.

One specimen taken in the Gunnison at Delta; five in the Green River. Apparently not ascending the streams so far as the preceding.

Comparing specimens of similar size, *Gila elegans* has a higher nape and back, more depressed head, slenderer caudal peduncle, larger fins, and smaller scales on

back and below, although the number in the lateral line is about the same as in *G. robusta*. Scales along middle line of back before dorsal obsolete or nearly so; mouth a little larger than in *Gila robusta*. Least depth of caudal peduncle,  $1\frac{2}{3}$  in maxillary ( $1\frac{1}{4}$  in *G. robusta*). *Gila emoryi* Baird & Girard seems to be the young of *G. elegans*.

7. *Ptychocheilus lucius* Girard. *White Salmon*.

This species is generally common, specimens having been taken by us in the Gunnison River at Delta, in the Uncompahgre and in Green River. It reaches a weight of 80 pounds or more in the large streams, and is justly regarded as a good food-fish.

The young have always a black caudal spot, the fins are slightly reddish, and there is a slight trace of a pale lateral band below a darker one.

The scales are about 87 instead of 104 as shown in Girard's figure. Maxillary  $2\frac{3}{5}$  in head.

8. *Agosia yarrowi* Jordan & Evermann, sp. nov., *Minnow*. (*Apocope oscula* Cope and Yarrow; not *Argyreus osculus* Girard).

This species is very abundant in the small streams in the mountain meadows. In the larger streams it is less common, and in the rivers below the mountains it is rare. Our specimens are from Tomichi Creek, Gunnison River at Gunnison and at Delta, Uncompahgre River, Green River, Eagle River at Gypsum, Rio de las Animas Perdidas, Rio Florida, and Leitner's Creek.

Description from specimens from Tomichi Creek. Head  $4\frac{1}{8}$  in length; depth 5 to  $5\frac{1}{2}$ ; D. 7; A. 7; scales 74, 80, 77, 80, 83, 80, 83, 79, 75, 76, 74, 74, 80, 82, in 14 specimens, the average being about 16-80-13. Length from 2 to 5 inches.

Body little compressed, elongate; head long and rather heavy, bluish; snout short, obtuse,  $2\frac{2}{3}$  to  $2\frac{3}{4}$  in head; eye small,  $5\frac{1}{2}$  to 6; barbel small but distinct. Upper lip, in about half the specimens, separated from the skin of the snout by a fold, as usual in *Agosia* and most other *Cyprinidae*. In the rest of the typical examples the upper lip is joined mesially to the snout by a distinct frenum. These specimens, although to all appearance specifically identical with the others, would belong to the genus *Rhinichthys*, as now defined. The frenum is, however, considerably narrower than in *Rhinichthys*, and this fact may for the present serve to separate the species from that genus. Lips full; maxillary about  $3\frac{1}{2}$  in head; scales small; lateral line complete; dorsal fin well backward, its insertion about midway between base of caudal and eye. Pectoral  $1\frac{1}{3}$  in head, usually not quite reaching to ventrals, the latter reaching past vent. Caudal large. Color dark olive, more or less mottled above with black; sides with two ill-defined dark lateral bands, the interspace paler. Axils of fins mostly crimson in life as in related species. This species seems to differ from *A. nubila* and *A. adobe* in its smaller scales, these species having less than 70. Its scales are larger than in *Agosia oscula*.

In the type of *Argyreus osculus*, from Rio Babocomori, in Arizona, there are 90 scales. In the types of *Apocope ventricosa* Cope, from "Arizona and New Mexico," there are 89. We have therefore been compelled to regard our specimen as different from the original *Argyreus osculus*=*ventricosa*.

We have named this species for our friend, Dr. Henry C. Yarrow, in recognition of his work on the fishes of the Rio Colorado.

9. *Salmo mykiss* Walbaum (var. *pleuriticus* Cope).

Trapper's Lake, Eagle River, Cañon Creek, Sweetwater Lakes, Gunnison River, Rio Florida.

Trout are very abundant in all the headwaters of the Colorado and its tributaries wherever the waters are clear and cold. These trout have for the most part the dark spots large and chiefly confined to the posterior part of the body. One specimen from Trapper's Lake is coarsely and closely spotted from head to tail. Others from Eagle River at Gypsum are finely spotted on tail only, repeating the coloration of var. *macdonaldi*, from which they differ mainly in the shorter opercle and the less elongate body.

As a whole, the trout from the Colorado approach most nearly to those from the Rio Grande, but in the specimens counted by me the scales are a little longer in the Rio Grande fish.

Coloration in life of trout from Trapper's Lake, olivaceous; lower fins red, sides with a crimson-red band on level of pectoral, present in every one of eleven specimens. Flesh mostly salmon red. Black spots large, varying much in number, in some much more numerous on the tail; others are closely spotted even to tip of snout. Some with the head spotted, others not. Spots extending low on the sides, usually some on the anal; dorsal and caudal profusely spotted in all.

The trout from Cañon Creek seem to be the young of these; smaller, paler, the spots more confined to the tail. Red markings rather orange than crimson. All show traces of a red lateral band and have the lower fins red. All have much red under the throat and on branchiostegals and opercle. Some of them show round orange blotches on lateral line anteriorly.

Trout from Sweetwater Lake are like those from Trapper's Lake, but with the spots encroaching more on the belly.

Trout from Eagle River show more resemblance to the yellow-fin of Twin Lakes in the small size of the spots and the plain coloration. Their place seems, however, to be in var. *pleuriticus* with the others from the Colorado Basin.

#### 10. *Cottus bairdi punctulatus* (Gill). Bullhead.

Our specimens correspond with *Uranidea punctulata* Gill, from the head of Green River, except that the dark spots on the body are very irregularly developed and often wanting. They differ from most Eastern examples in the form of the head, which is blunter, lower, and more rounded, and without a distinct medial depression. The black bars usually found in Eastern examples is wanting in these, and in these there are no prickles on the skin behind the axil, nor anywhere else. The specimens found in the headwaters of the Missouri in Yellowstone Park seem to be fully identical with ours from the basin of the Colorado.

*Cottus punctulatus* may prove to be a species distinct from *C. bairdi* (= *C. richardsoni*, etc.), but some specimens examined by us (Torch Lake, Michigan) seem to be intermediate. Var. *punctulatus* is thus far known from the Upper Missouri and the Upper Colorado. Specimens were obtained by us in Eagle River, Roaring Fork, Gunnison River, at Delta, Rio Florida, Leitner's Creek and Rio de las Animas Perdidas. In the Eagle and Florida it is excessively abundant, as in the streams of the Yellowstone Park.

### UTAH.

To the east of the Wahsatch Mountains, Utah is chiefly an arid desert, with little rain-fall, scarcely any vegetation, and no permanent streams of any importance except the Colorado itself. The whole surface is made up of adobe hills and barren mesas,

deeply scored by the erosion of the brief rainy season. Except in the Colorado and in a few brooks and ponds near the crest of the Wahsatch, there are no fishes in eastern Utah. West of the divide of the Wahsatch lies the Great Basin. This is a high, arid plain, largely alkaline, and crossed by numerous short but abrupt mountain chains.

#### E.—SALT LAKE BASIN.

The lowest part of this basin is occupied by the Great Salt Lake, while other depressions are occupied by other lakes or alkaline sinks, also without outlet. The largest of these in Utah is Sevier Lake. Into these lakes and sinks flow the waters of multitudes of clear streams and springs having their source in the mountains. Most of these streams are well stocked with trout and whitefish in their upper courses. The water farther down is now nearly all consumed by the irrigating ditches of the Mormon settlers, and in Utah, as in Colorado, millions of young trout are each year destroyed by venturing out into these ditches, whence they are scattered over the fields and left to perish. All the valleys of western Utah were formerly covered by the waters of a great post-glacial lake known to geologists as Lake Bonneville. The evidences of the former existence of this lake are everywhere visible in the form of terraces on the sides of the mountains at a considerable height above the present levels of Utah Lake and the Great Salt Lake. Lake Bonneville had probably its outlet to the north through the Snake River. The former connection of the now isolated lakes in the Great Basin must explain the close similarity in the fish fauna, but we can not tell how close this resemblance is until the fishes of the Great Basin of Nevada, the bed of the former Lake Lahontan, are thoroughly investigated. Collections were made by us at different points in the Salt Lake Basin and in the basin of the Sevier River at Juab.

1. *Utah Lake*.—Utah Lake is about 25 miles long by 10 broad, of irregular form, and surrounded by high mountains. It is shallow near the shore but deep in the middle and in its channels. The surface water is in summer quite warm, while on the bottoms it is very cold. The lake is extremely low in summer, there being but little water running in the outlet. The water is then of a milky blue color and decidedly alkaline. Our collections were made with a long seine, kindly furnished to us by Peter Madsen and his sons, of Provo. This seine was used in a deep channel in the southwestern part of the lake below the mouth of the Spanish Fork. Fishes taken in the lake are marked U in the following list.

2. *Provo River*.—The Provo River is a considerable stream, the largest rising in the Wahsatch range. In the upper course it contains no fishes except trout. Where it leaves the cañon at the foot of the Wahsatch it is very clear and icy cold (temperature about 53°). It flows over a bottom of rounded shingle and small boulders. In and immediately below the cañon it contains only trout and some whitefish. The bottom has no vegetation. Lower down towards the town of Provo the water becomes gradually warmer; the bottom is covered with plants and the banks lined with bushes. The bottom is here of fine gravel and the temperature about 63°. The species taken at this point above the city are marked P in the list. Still lower down the water is all drawn off for irrigation, and only the seepage fills the river bed. Near the mouth of the river, near Madsen's farm, the bottom is of fine gravel, sand, and mud; the water is sluggish and warm (temperature about 78°). The fishes found here are marked M. In Mr. Madsen's earp pond, a muddy pond formed from artesian water, we found *Leuciscus atrarius* and *Hemitremia phlegethontis* very abundant. They had come in

through the overflow of the pond and the chub has proved very mischievous, devouring the eggs and fry of the carp and checking all increase.

3. *Jordan River*.—Jordan River is the outlet of Utah Lake. It is a clear or slightly milky stream, rather warm in summer with moderate current and a bottom of sand and adobe. Chubs, suckers, and sometimes whitefish are everywhere plenty. Trout were common before they were excluded by the dams of the irrigating ditches. These now consume all the water of Jordan River in summer, the river bed being filled up by seepage and by the overflow from the numerous artesian wells. Jordan River was seined at a point just below a dam 4 miles southwest of Salt Lake City. The stream is here about 2 rods wide and 2 to 5 feet deep, the bottom being of adobe; temperature about 63°. Species found in Jordan River are marked J.

4. *Great Salt Lake*.—The waters of the lake are intensely salt and no fishes ever enter them. The only living thing in the water is a small brine shrimp.

#### FISHES OF THE SALT LAKE BASIN.

##### 1. *Catostomus ardens* Jordan & Gilbert. U., J. "Red Horse Sucker;" "Mullet."

This species is the common sucker of Utah Lake, existing in millions and far outnumbering all the other species combined. The young are very abundant in Jordan River. This species reaches a weight of about 2 pounds. It is very close to *Catostomus teres*, almost the only tangible differences being in the rather smaller scales, the usually longer mandible, 3 to 3½ in head in the adult in *C. ardens*, 3½ to 3¾ in *C. teres*, and in the broader upper lip.

Upper lip rather small, with four or five rows of coarse papillæ. Snout forming a moderate "nose;" mandible little oblique or nearly horizontal; scales 63 to 71. Dorsal rays 12 or 13, the fin longer, lower, and less straight on the free edge than in *C. fecundus*. Base of dorsal in adult, 1⅓ to 1⅔ in head; longest ray, 1⅓ to 1 in base of fin; head, 4 in length; eye, small; snout, 2½ in head, pectoral and caudal rather short.

Color of specimens in the lake darker than that of *C. fecundus*, the lower fins dusky. Spawns in March.

##### 2. *Catostomus fecundus* Cope and Yarrow. Webug.

The "Webug" sucker is found only in the lake. It is much less abundant than the preceding, and reaches a smaller size, rarely weighing more than a pound.

It has a small mouth at the end of a long, projecting snout, which forms a distinct nose; mandible very oblique, almost as in *Chasmistes*, its length 2¾ to 2⅘ in head. Snout 2⅙.

Lips wide but smoothish, the upper with about four rows of large papillæ. Scales 64; D. 11 or 12. Dorsal fin shorter and usually higher than in *C. ardens*, its base in the adult 1½ in head, its longest ray usually a little shorter than the base of the fin. Lower fins long. Color rather pale.

##### 3. *Chasmistes liorus* (Jordan). The "Sucker." U. (Plate V, Fig. 13.)

Abundant in Utah Lake, reaching a weight of 3 pounds. It spawns in June.

Mouth very large, oblique, with full lips, which are non-papillose. A distinct nose; mandible 2¾ in head. D. 13. Scales, 66. Fins large. Dorsal low, its free margin a little concave. Longest ray ⅝ base of fin, which is 1½ in head.

##### ✓ 4. *Pantosteus generosus* (Girard). Mountain Sucker. P., J.

Very common in the upper Provo and in the Jordan. Not exceeding 8 inches in

length; the specimens all slender, with short small head, corresponding to *P. platyrhynchus* of Cope.

5. *Rhinichthys dulcis luteus* (Garman). P., J.

Abundant in the Jordan and Provo with the preceding. It is possible that some of the species of *Apocope* of Cope were based on this, which is certainly the commonest species of this type about Provo. Some of the specimens recorded by me as *Apocope vulnerata* (Proc. U. S. Nat. Mus., 1880, 462) belong to it, as I find on re-examination. The Utah fish is almost or quite identical with the ordinary *dulcis*, but the number of scales below the lateral line seems on an average to be slightly greater (usually about 14 above ventrals, while *dulcis* has 11 or 12).

6. *Agosia nubila* (Girard). P.

Rather scarce, and seen only at Provo. These specimens seem to agree fully with those taken in Heart Lake, in the Yellowstone Park. Body robust; head blunt and short; the snout 3 in head, little projecting beyond the mouth. Head  $4\frac{1}{3}$  in length; depth, 5. Eye  $4\frac{2}{3}$  in head; pectoral rather short, not reaching ventrals. Scales, 72; 65 in two specimens. This species seems to correspond to *Apocope carringtoni*, *vulnerata* and *rhinichthyoides* of Cope, and the *Apocope henshawi* and *cousi* are not evidently different. The species of this genus are distinguished with great difficulty. The following analysis gives the chief characters which I am able to find. This arrangement is provisional only, and further study may reduce the number of recognizable forms.

- a. Scales very small, about 90; snout obtuse, little projecting. Gila River and Lower Colorado Basin.  
(*notabilis* = *ventricosa*) ..... *Oscula*.
- aa. Scales small, about 80; snout blunt and heavy,  $2\frac{3}{8}$  to  $3\frac{3}{8}$  in head; upper lip often joined to the snout by a narrow mesial frenum; eye small. Upper Colorado Basin. (? *oscula* Cope & Yarrow, not Girard)..... *Yarrowi*.
- aaa. Scales moderate, 60 to 70.
- b. Head short, blunt, and heavy, 4 to  $4\frac{1}{2}$  in length; snout short, high, obtuse,  $3\frac{1}{2}$  to  $3\frac{1}{2}$  in head, its tip scarcely projecting beyond mouth; eye large, about  $4\frac{2}{3}$  in head, more than half snout; lateral line broken in the young. Great Basin and Upper Columbia River. (*Carringtoni* = *vulnerata* = *rhinichthyoides* = ? *henshawi* = ? *cousi*) ..... *Nubila*.
- bb. Head long,  $3\frac{3}{8}$  to  $3\frac{5}{8}$  in length, with long, rather low, broad snout, pointed in profile,  $2\frac{2}{3}$  to  $2\frac{3}{4}$  in head; eye small, 5 to 6 in head; little more than half snout, lateral line complete. Sevier River..... *Adobe*.

7. *Leuciscus montanus* (Cope). Silver-side Minnow. P., J.

(*Clinostomus montanus* and *C. tania* Cope; ?*Phoxinus cleavelandi* Eigenmann & Eigenmann.)

This is the most abundant fish in the Provo River above the city of Provo. It reaches a length of about 4 inches, and is useful as food for the trout. In form, color, size, and habits, this fish bears a strong analogy to *Notropis eoccogenis* of the Alleghany region. I can not separate *L. tania* from *L. montanus*. The anal rays vary from 10 to 13, the usual number being 10 or 11. Dr. Gilbert has examined the types of both species and finds no difference. *Phoxinus cleavelandi* Eigenmann & Eigenmann (West. Amer. Scient., Nov., 1889, 149), from Napa Springs, California, agrees perfectly with *L. montanus*, but the locality is remote. In life, *L. montanus* is greenish blue below the eye; a red band below lateral line, ceasing at front of anal. Dark lateral band almost blue.

8. *Leuciscus copei* Jordan & Gilbert. Leather-side Minnow. P. (*Squalius aliciae* Jony.)

Abundant in the Upper Provo. There is no difference between *Squalius copei* from Bear River, a tributary of the Great Salt Lake and *S. aliciae* described soon after from

Provo River. To this species belongs *Gila egregia* of Cope from Beaver River, but the specimens called *Gila egregia* from the Rio Grande, by Cope & Yarrow, must be some other fish. The type of *Tigoma egregia* Girard has 66 scales. *L. copei* has the scales about 80. It is not unlikely that this species is the original of *Tigoma gracilis* Girard. The types of *Tigoma gracilis* are, however, lost, and the description is too vague to permit identification. The name *gracilis* is also preoccupied in *Leuciscus*. The axils in the males are deep scarlet in *Leuciscus copei*.

9. *Leuciscus atrarius* (Girard). Chub. M., U., J. (*Siboma atraria* Girard; *Tigoma obesa* Girard; *Tigoma squamata* Gill; *Squalius rhomaleus* Jordan and Gilbert; *Squalius cruoreus* Jordan and Gilbert; ? *Hybopsis bivittatus* Cope; ? *Hybopsis timpanogensis* Cope.)

Excessively common in all waters of the Great Basin except the coldest. It reaches a length of more than a foot, and is very destructive to the young trout, which it captures as they descend the rivers. Reaching a larger size than most of the other chubs, it becomes a food fish of some importance. As the fish grows older, the head becomes proportionately more depressed, and the back more prominent. Such large specimens have become the type of *Squalius rhomaleus*. These large chubs swarm in Utah Lake, and may be taken in the seine, with trout and suckers. Young specimens of the same species were named *Squalius cruoreus*. I have re examined the types of the latter species and find them to be the young of *L. atrarius*. The two species described as *Hybopsis bivittatus* and *H. timpanogensis* Cope are doubtless young chubs, and probably also of this species.

Dr. Gilbert has compared the types of *Tigoma obesa* with those of *Squalius cruoreus* and finds the two identical. The types of *obesus* are bloated by poor alcohol. The name *obesus* is preoccupied by *Leuciscus obesus* Storer.

The species of *Leuciscus* taken by us during the present summer may be thus compared:

- a. Scales very small; lateral line 80; body rather elongate, the depth about 4 in length; anal small, with 8 rays; olivaceous, dark-punctate, sides more or less silvery..... *Copei*.
- aa. Scales moderate, 52 to 67.
  - b. Anal fin rather small, its rays about 8.
    - c. Scales rather small, 60 to 67; head rather pointed, the mouth moderate; depth about  $4\frac{1}{2}$  in length ..... *Pulcher*.
    - cc. Scales larger, 52 to 58.
      - d. Scales before dorsal 23 to 28; back becoming elevated with age; dorsal over or rather behind ventrals ..... *Atrarius*.\*
  - bb. Anal fin large, its rays 10 to 13; scales 55 to 58; body more or less compressed.
    - e. Anal rays usually 10 or 11; snout rather blunt; jaws equal; eye large, about 3 to  $3\frac{1}{2}$  in head; depth about 4; sides with a dusky lateral band; sides and belly crimson in the male..... *Moutanus*.
    - ee. Anal rays usually 12 or 13; its base  $6\frac{1}{2}$  in body; snout rather sharp; the lower jaw projecting; eye moderate, 4 to 6 in head in adult; depth  $3\frac{3}{4}$  to 4 in length; sides with a plumbeous lateral band, with red above and below it in the males.

*Hydrophlox.*

\* It is not unlikely that *Protoporus dominus* Cope is based on an immature example of this species. The type is from the Snake River at Fort Hall, Idaho. It was 2 inches long, and had the lateral line incomplete.

10. *Hemitremia phlegethontis* (Cope). M.

Extremely common in the pools of water about the mouth of Provo River and in the carp-ponds. It reaches a very small size, none being seen more than  $1\frac{1}{2}$  inches in length.

Head,  $3\frac{3}{4}$ ; depth,  $3\frac{1}{3}$ . Scales, 36; 17 before dorsal, 11 between dorsal and ventrals. Lateral line obsolete, not a pore being developed. Body short, deep, compressed; head short, compressed, with blunt snout. Mouth short, oblique, the lower jaw projecting; maxillary reaching to front of eye; pectorals about reaching ventrals, the latter to past front of anal.

Color, dark olive; a dark vertebral streak; a dusky streak along side and a very faint caudal spot; scales covered with dark dots. Males in life with fins and sides yellow; axil red; sides of belly dashed with red.

Three of the American species referred to the genus *Phoxinus*, *vittatus* (*flammeus* Jordan & Gilbert), *phlegethontis* and *milnerianus*, differ notably from the European *Phoxinus phoxinus* (L.) in the size of their scales. These are 36 to 45 in these species, while in *Ph. neogaeus* the scales are about 80, and *Ph. phoxinus* still smaller.

For these large-scaled species, we may retain the name of *Hemitremia*, originally proposed for *Hemitremia vittata*, by Professor Cope. The name *Hemitremia* was wrongly associated with *Notropis heterodon* and its allies, before the relations of the typical species were understood.

11. *Salmo mykiss* Walbaum, var. *virginalis* Girard. Trout. P., V. (*Salmo virginalis* Girard; *Salmo utah* Suckley.)

Very abundant in Utah Lake; spawning in the shallow parts of the lake and in the tributary streams which it ascends to the headwaters. The Utah lake trout have the coloration of the Oregon trout, var. *clarki*, but the dark spots are usually somewhat smaller. The only differential character lies in the greater size of the scales, the number of these in a horizontal series being usually about 150.

The large trout of the lakes are deep green in color, the sides silvery, and the dark spots small and faint. Lower fins red. Upper fins yellowish. The usual red dash under the throat is never absent in this species. An excellent account of the habits and economic value of the Utah Lake Trout has been given by Dr. Henry C. Yarrow, (Rept. Lieut. Wheeler, Expl. W. 100th Meridian, V, Zool., pages 685, 693).

No better trout for the table exist than those of the Utah Lake variety. They reach a weight of 3 to 10 pounds. In a single haul of the large seine made in a channel on the south side of the lake, fifty trout ranging from 2 to  $3\frac{1}{2}$  pounds were taken. With these were taken six June suckers (*Chasmistes liorus*) weighing about 3 pounds each, two hundred "Mullet" (*Catostomus ardens*) weighing about 2 pounds each, one webug (*Catostomus fecundus*) weighing 1 pound, and about two hundred chubs (*Leuciscus atrarius*), the largest weighing  $1\frac{1}{4}$  pounds. This list gives a fair index to the relative abundance of the larger fishes of the lake. The "Sucker," and "Webug" are, however, at times proportionately more abundant.

12. *Coregonus williamsoni* Girard. P., J. Mountain Herring (White fish.)

This pretty little fish is common in the Provo River above the city, where it may be readily taken with the hook. It is also occasionally taken in the Jordan. One specimen was procured by us with the seine in the Jordan and several in the colder Provo. It is not a lake fish, being chiefly found in the running waters. Our specimens agree

fully with others from Walla Walla, and differ from those taken in the headwaters of Madison River in the deeper body, longer head, larger scales, and higher fins.

The following gives the measurement of a number of specimens:

Locality.	Head.	Depth.	Scales.	D. longest ray in head.	P. in head.	V. in head.
Jordan River .....	4½	4½	77	1¼	1½	1½
Provo River .....	4½	4½	76	1¼	1½	1½
Madison River .....	4½	5	82-85	1½	1½	1½

**13. *Cottus bairdi punctulatus* Gill. P. (*Uranidea wheeleri* Cope.)**

A few specimens, dark in color and much mottled; axil a little rough, otherwise like specimens from the Colorado basin and from Gibbon River.

**14. *Cottus semiscaber* (Cope).**

Not rare in the Provo; distinguished from the preceding by its prickly skin; also paler in color, with much black mottling. D. VII, 16. This species is well described by Jordan & Gilbert, Synopsis, p. 695.

#### FISHES OF THE SEVIER RIVER.

The Sevier River rises in Panquitch Lake, in southern Utah. This lake is in the mountains and is noted for its trout and whitefish. The river, after leaving the mountains, flows northward through a desert country. Its largely alkaline waters are drawn off for irrigation and are reduced by evaporation. It is ultimately lost in a large alkaline pool or sink known as Sevier Lake. In this lake are no fishes.

The Sevier River was seined about the railroad bridge, some 7 miles west of the village of Juab. The river has here a bottom of gravel and firm sand or adobe. It is about 2 rods wide and 1 to 4 feet deep. The water is somewhat muddy, warm (73°), and full of small fishes. It is said that trout (*Salmo mykiss virginalis*) and whitefish (*Coregonus williamsoni*) descend the river in the spring as far as Juab.

In this and similar streams through the Great Basin catfishes might be placed to advantage.

Chicken Lake is a shallow alkaline pond, about a mile long by half a mile broad, between Juab and the Sevier River. It is muddy and full of bulrushes where shallow, and of *Conferve* and *Myriophyllum* where deep. It is fed by springs. Its outlet is a small brook which flows into the Sevier at the railroad bridge. The waters of Chicken Lake are alive with chubs (*Leuciscus atrarius*) and there are some suckers (*Catostomus*).

**1. *Pantosteus generosus* (Girard).**

Very abundant.

**2. *Catostomus ardens* (Jordan and Gilbert).**

Abundant, as in Jordan River.

**3. *Leuciscus montanus* (Cope).**

Common, very pale, as all fishes are in alkaline waters; no red and no black lateral stripes.

**4. *Leuciscus atrarius* (Girard).**

Exceedingly abundant; none seen large.

5. *Leuciscus copei* (Jordan & Gilbert).

Common; axil in male deep scarlet.

6. *Agosia adobe* Jordan and Evermann, sp. nov.

Very abundant in the Sevier River.

The *Agosia* of the Sevier River seems to be certainly distinct from *Agosia nubila* and from all the other species known to me. I am utterly unable to identify it with any of the species described by Cope, nor can I see how most of these species differ from each other or from *A. nubila*. We therefore propose a new name for the Sevier species in allusion to the color of the fish and the bottoms it frequents.

Head  $3\frac{2}{3}$  to  $3\frac{5}{6}$  in length; depth  $4\frac{1}{2}$  to 5. D. 8; A. 7. Scales 12-63 to 70-10. Length of types 2 to 4 inches.

Body rather slender and elongate, formed as in *Rhinichthys*. Head long and low, sharp in profile, the anterior profile forming an even and gentle curve from tip of snout to front of dorsal. Snout sharp, long, more than  $\frac{1}{3}$  of head,  $2\frac{3}{8}$  to  $2\frac{5}{8}$ , usually  $2\frac{3}{8}$ , its tip projecting considerably beyond the thick upper lip. Mouth rather larger than in *A. nubila*, the maxillary extending to behind nostril; barbel well developed. Eye small, about two in snout, 5 to  $5\frac{1}{2}$  in head. Lateral line complete. Dorsal inserted midway between front of eye and base of caudal. Pectoral usually shortish and not reaching ventrals, but sometimes passing them. Fins rather high. Caudal well forked, the lower lobe slightly longest.

Color grayish-olivaceous above with a dark lateral band, fins and belly pale; back with some dark dots.

7. *Cottus bairdi punctulatus* (Gill). (*Uranidea wheeleri* Cope.)

Abundant in Sevier River. Color clay-gray, everywhere finely reticulate with olive, the pattern on head very fine. Skin perfectly smooth. These specimens agree fully with others from Gibbon River, except in the shade of the ground color, which in the Sevier corresponds to the bottom of adobe.

UNIVERSITY OF INDIANA, January 11, 1890.

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FOILD-OUT  
HERE



Topography taken from maps published in 1886, by the U. S. Geological Survey

No. 149

## 2.—A RECONNOISSANCE OF THE STREAMS AND LAKES OF THE YELLOWSTONE NATIONAL PARK, WYOMING, IN THE INTEREST OF THE UNITED STATES FISH COMMISSION.

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BY DAVID STARR JORDAN.

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[Plates VI to XXII.]

In the summer of 1889, at the instance of Capt. F. A. Boutele, U. S. Army, acting superintendent of the Yellowstone National Park, a brief visit was made to the Park by Hon. Marshall McDonald, U. S. Commissioner of Fish and Fisheries. It was made very evident from the observations of the Commissioner that much could be done towards enhancing the attractions of the great national "pleasuring ground" by the stocking of those of its various streams and lakes which are now destitute of fishes.

In September, 1889, the writer was requested by the Commissioner to make a visit to the Park for the purpose of procuring exact data preliminary to the work of introducing trout and other fishes. Dr. Charles H. Gilbert was asked to assist in this work.

The memorandum of instruction ran as follows:

"A considerable portion of Yellowstone Park is a volcanic plateau, in which have been excavated the lakes Yellowstone, Shoshone and Lewis, and a number of smaller lakes. The drainage from this region reaches the headwaters of the Snake and Missouri Rivers by falls impassable to fish, most of which are within the limits of the Park, and some beyond the limits. The waters above these falls (the aggregate basins embracing an area of some 1,500 square miles), so far as my observation extends, are entirely barren of fish except Yellowstone Lake and its tributaries, in which the black-spotted trout, *Salmo purpuratus* [*Salmo mykiss*], is very abundant. I have proposed to undertake to stock these waters with different species of *Salmonidae*, reserving a distinct river basin for each.

"It is important to settle in advance what I believe to be the fact, that there is now an entire absence of fish fauna in the region above the falls, except Yellowstone Lake, and to determine precisely and fully the species to be found in the waters draining from the Park and below the impassable obstruction. It is also desirable to get information in regard to the parasitic flesh-worm which is so common in the Yellowstone trout, and to receive suggestions as to the study of this parasitic worm.

"The waters proposed to be stocked should also be examined with reference to the abundance of other forms of aquatic life which might serve as food for the fishes, both the fry and the adult. Special study in this regard should be made of the waters of

Lakes Shoshone and Lewis, which it is proposed to stock with the land-locked salmon and Loch Leven trout.

"Capt. F. A. Boutelle, U. S. Army, acting superintendent of the Park, will be notified by telegraph of your proposed exploration, and requested to give you every facility for it."

Other engagements rendered it impossible for us to start before September 24, 1889, a late date for such work, as the climate of the Park is subarctic, and serious snow-storms may be expected at any time after the middle of September. We were very fortunate, however, as we arrived in the Park just after a storm, and throughout our stay Indian-summer weather prevailed and no time was lost on account of snow.

The following is the itinerary of the trip:

September 24.—Left Bloomington, Ind., in company with Dr. Charles H. Gilbert and Mr. William W. Spangler, librarian of the Indiana University, volunteer assistant.

September 27.—Arrived at the Mammoth Hot Springs.

September 28.—Examined Gardiner River, above and below the Osprey Falls; also visited Obsidian and Glen Creeks.

September 30.—Scined Gardiner River about the mouth of Hot River.

October 1.—Started with tents, pack-horses, etc., on a tour of the Park, accompanied by Elwood Hofer, guide; David Rhodes and John Innes, packers; and Richard Randall, cook. Visited Lava Creek and its falls, and Black-tail Deer Creek. Encamped at night at Yancey's on Elk Creek.

October 2.—Visited Tower Creek and Antelope Creek, crossed Mount Washburn and encamped at its base on the south side.

October 3.—Ascended the Yellowstone River and encamped on its banks about  $1\frac{1}{2}$  miles south of the Giant's Cauldron.

October 4.—Encamped on Yellowstone Lake, on the north shore of the western arm or "Thumb."

October 5.—Passed around the "Thumb" of the Lake; ascended Solution Creek, and encamped on Riddle Lake.

October 6.—Crossed the Divide to Heart Lake; examined Witch Creek.

October 7.—Went from Heart Lake across the base of Red Mountain; passed Lewis Lake to Shoshone Lake; encamped at the mouth of Heron Creek.

October 8.—Went from Shoshone Lake across the Divide to Firchole River; encamped at the Upper Geyser Basin.

October 9.—Went down the Firchole River to its falls; encamped on Cañon Creek.

October 10.—Examined Gibbon River, Twin Lakes, Obsidian Creek, etc. Reached Mammoth Hot Springs in the evening.

October 11.—Received fishes from Horsethief Spring, obtained by Mr. E. R. Lucas. Left Mammoth Hot Springs.

October 15.—Reached Bloomington, Ind.

Our trip was necessarily considerably hurried, though long enough to enable us to make out the leading points of the problems in question. A more complete survey of the Park and the surrounding region would enable us to work out in detail the distribution of the fishes found lower down the streams. The distribution of the Miller's Thumb or Blob (*Cottus bairdi punctulatus*) needs special study. The distribution and conditions of life of the parasitic worm (*Dibothrium cordiceps* Leidy), found in the trout of Yellowstone Lake, as well as those of the larger worm found in the sucker of Witch Creek, will demand a whole summer's attention from some one familiar with the subject.

In all our work we had the cordial and intelligent co-operation of Capt. F. A. Boutelle, acting superintendent of the Park, of Lieut. W. E. Craighill, of the U. S. Engineer Corps, and of Lieutenant Edwards, U. S. Army. We were fortunate in securing

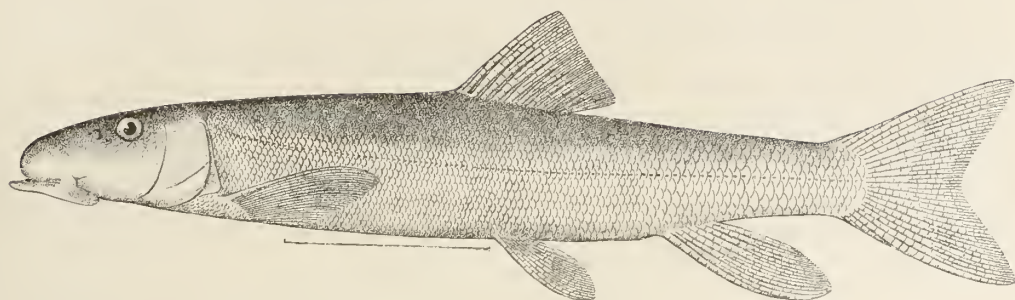


FIG. 1. GRAY SUCKER (*Catostomus griseus*). (See page 46.)

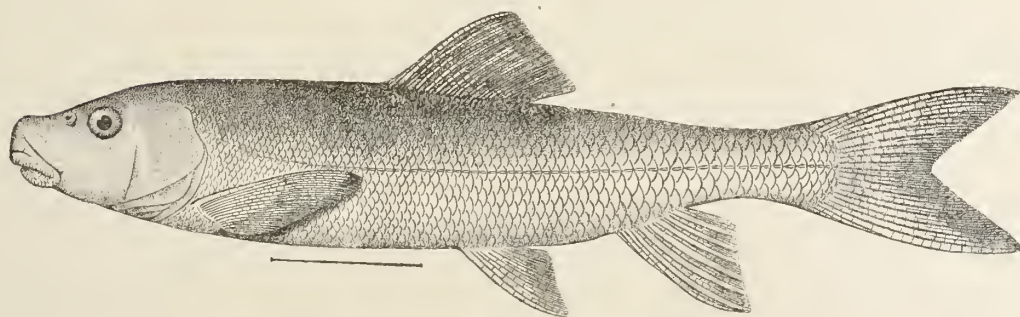


FIG. 2. RED HORSE SUCKER (*Catostomus ardens*). (See page 47.)

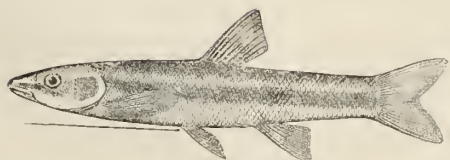


FIG. 3. THE DACE (*Rhinichthys dulcis*).  
(See page 48.)



FIG. 4. (*Agosia nubilus*). (See page 48.)



the services, as guide, of Mr. Elwood Hofer, to whom we are indebted for much valuable help. Mr. E. R. Lucas, of the distributing division of the U. S. Fish Commission, also aided us materially by collecting specimens from tributaries of Madison River and Henry River. Mr. Arnold Hague, of the U. S. Geological Survey, also gave us considerable valuable information.

The following is a classified list of the waters examined, those lakes and streams containing trout being printed in italics:

## Yellowstone Basin:

*Yellowstone River.*  
*Yellowstone Lake* (altitude, 7,741 feet).  
*Riddle Lake* (altitude, 7,900 feet).  
*Solution Creek.*  
 Bridge Bay Creek.  
 Arnica Creek.  
*Trout Creek.*  
*Alum Creek.*  
 Cascade Creek.  
 Sulphur Creek.  
*Antelope Creek.*  
 Tower Creek.  
 Lost Creek.  
 Elk Creek.  
 Oxbow Creek.  
 Geode Creek.  
*Black-tail Deer Creek.*  
*Lava Creek.*  
*Lupine Creek.*  
*Gardiner River.*  
 Twin Lakes.  
 Obsidian Creek.  
 Beaver Lake.

## Yellowstone Basin—Continued:

Winter Creek.  
 Indian Creek.  
 Glen Creek.

## Madison Basin:

*Madison River.*  
 Firehole River.  
 Iron Spring Creek.  
 Little Firehole Creek.  
 Goose Lake.  
 Nez Percé River.  
*Gibbon River.*  
*Cañon Creek.*  
*Horseshief Spring.*

## Snake River Basin:

Shoshone Lake (altitude, 7,740 feet).  
 Heron Creek.  
 Lewis Fork.  
 Lewis Lake (altitude, 7,720 feet).  
*Heart Lake* (altitude, 7,469 feet).  
*Witch Creek.*  
 Howard's Creek.  
 Henry's Lake.

The Yellowstone Park is a high plateau, having a general elevation of 7,000 to 8,000 feet above the sea. Its entire surface, with the exception of the Gallatin range of mountains in the northwest, and some granitic summits in the northeast, is covered with lava, with its varieties of obsidian, rhyolite, etc. This mass of lava covers to a great depth what was previously a basin in the mountains. According to Mr. Hague, the date of the lava flow is probably Pliocene. Its existence was of course fatal to all fish life in this region. Since its surface has become cold, the streams flowing over it, most of them now wholly unaffected by the heat within, have become well stocked with vegetable, insect, and crustacean life, but are for the most part destitute of fishes. The cause of this absence of fishes is to be found in the fact that nearly all the streams of the Park on leaving the lava beds do so by means of vertical water-falls situated in deep cañons. Except in the Yellowstone and its tributaries, in Gibbon River and in Lava Creek, no fishes have been found above these falls, and the presence of fishes in the Upper Yellowstone and Lava Creek is doubtless due to the imperfect character of the water-sheds separating these streams from others.

The following is a list of the water-falls in the Park, supposed to be unsurmount

able by trout. No account is here taken of the numerous falls in small brooks or in mountain torrents unsuited to fish life:

Great Falls of the Yellowstone, 308 feet high.  
 Upper Falls of the Yellowstone, 109 feet high.  
 Crystal Falls in Cascade Creek, 129 feet high.  
 Tower Falls in Tower Creek, 132 feet high.  
 Undine Falls in Lava Creek, 60 feet high.  
 Lower Falls in Lava Creek, 50 feet high.  
 Wraith Falls in Lupine Creek, 100 feet high.  
 Falls in Slough Creek.  
 Osprey Falls in Gardiner River, 150 feet high.  
 Rustic Falls in Glen Creek, 70 feet high.

Virginia Cascades in Gibbon River, 60 feet high.  
 Gibbon Falls in Gibbon River, 80 feet high.  
 Keppler's Cascade in Firehole River, 80 feet high.  
 Firehole Falls in Firehole River, 60 feet high.  
 Falls in Lewis River, 80 and 50 feet high.  
 Moose Falls on Crawfish Creek.  
 Union Falls on Mountain Ash Creek.  
 Terraced Falls and Rainbow Falls on Falls River.  
 Iris Falls and Colonnade Falls on Bechler River.

Outside the Park the falls in Clarke's Fork of the Yellowstone exclude fish from that river, and perhaps the great Shoshone and American Falls in Snake River exclude from the upper part of the stream the fauna of the Lower Columbia. Another supposed obstacle to the spread of fish life in the Yellowstone Park is the presence of the innumerable hot springs, solfataras, and geysers, for which the region is famous. Although these springs exist in almost every lake basin, cañon, or other depression in the Park, we do not think that in their present condition, at least, they would stand in the way of the stocking of the streams and lakes with fishes.

The water of the geysers and other calcareous and silicious springs does not appear to be objectionable to fishes. In Yellowstone Lake trout are especially abundant about the hot overflow from the Lake Geyser Basin. The hot water flows for a time on the surface, and trout may be taken immediately under these currents. Trout have also been known to rise to a fly through a scalding hot surface current. They also linger in the neighborhood of hot springs in the bottom of the lake. This is probably owing to the abundance of food in these warm waters, but the fact is evident that geyser water does not kill trout.

In Heart Lake trout were found most plentiful about the mouth of the Warm Witch Creek. Suckers and chubs (*Leuciscus atrarius*) ascend this creek for some distance, although half its water comes from geysers and hot springs. The chubs are found in water in which the temperature is about 85° Fahr.

The Hot River, which drains the Mammoth Hot Springs, flows into Gardiner River. Trout abound about the mouth of this stream, and here, as in numerous other places in the Park, the conventional trick of catching a trout in cold and scalding it in hot water is possible. Below the mouth of this Hot River young suckers (*Catostomus griseus*) were found in a temperature of about 88°, and young trout in a temperature of about 75°.

Miller's Thumbs abound in the Gibbon River, about the hot springs. Three were found boiled in the edge of the river below Elk Park, at the mouth of a hot tributary. The volume of hot water poured into any river is greatest in the Firehole, below the upper Geyser Basin. The stream, however, is hardly warm, and the water has little mineral taste, though the abundant vegetation gives it something of the flavor of stewed plants. Even this stream, it would seem, is probably not so hot nor so heavily charged with mineral substance as to be unfit for trout. Its waters constitute a very dilute alkaline silicious solution. The following analysis of the waters of Firehole River is given by Gooch and Whitfield:\*

\* Bull. U. S. Geol. Survey, No. 47, page 57.

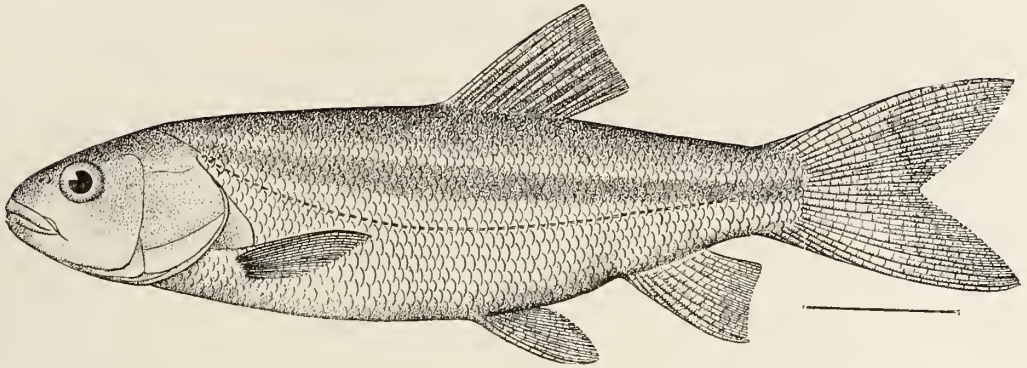


FIG. 5. THE UTAH CHUB (*Leuciscus atrarius*). (See page 48.)

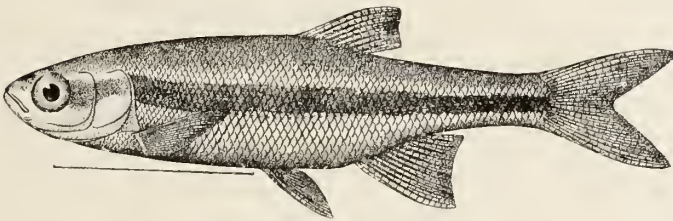


FIG. 6. (*Leuciscus hydrophlox*). (See page 48.)

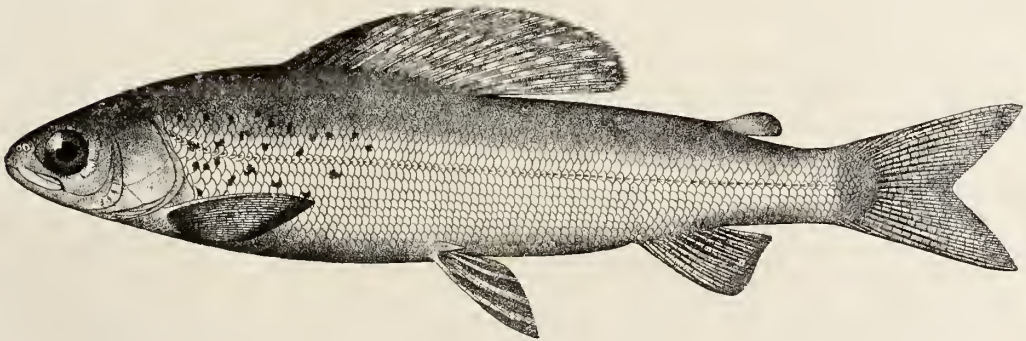


FIG. 7. THE GRAYLING (*Thymallus signifer*, var. *ontariensis*). (See page 49.)



[The sample was taken from above the mouth of Nez Percé River August 24, 1884; temperature 8° C ; reaction, alkaline; specific gravity, 1.00031.]

[Hypothetical combination.]

Constituents.	Grams per kilo- gram of water.	Per cent. of total material in solu- tion.	Constituents.	Grams per kilo- gram of water.	Per cent. of total material in solu- tion.
Na <sub>2</sub> CO <sub>3</sub> .....	0.1201	27.51	Na <sub>2</sub> B <sub>4</sub> O <sub>7</sub> .....	0.0087	1.99
Si O <sub>2</sub> .....	0.0965	22.10	Li Cl .....	0.0067	1.53
Na Cl .....	0.0867	19.86	Al <sub>2</sub> O <sub>3</sub> .....	0.0059	1.35
CO <sub>2</sub> .....	0.0457	10.47	Mg CO <sub>3</sub> .....	0.0024	0.55
K Cl .....	0.0325	7.44			
Ca CO <sub>3</sub> .....	0.0165	3.78		0.4366	100.00
Na <sub>2</sub> SO <sub>4</sub> .....	0.0149	3.42			

This analysis may be compared with that given by the same authors for the Gardiner River above and below the mouth of Hot River, in both of which localities trout are abundant.

[Gardiner River above Hot River, October 12, 1883; temperature 8° C.]

[Hypothetical combination.]

Constituents.	Grams per kilo- gram H <sub>2</sub> O.	Per cent. of mate- rial in solution.	Constituents.	Grams per kilo- gram H <sub>2</sub> O.	Per cent. of mate- rial in solution.
Ca CO <sub>3</sub> .....	0.0625	29.25	Al <sub>2</sub> O <sub>3</sub> .....	0.0079	3.70
Si O <sub>2</sub> .....	0.0469	21.95	K <sub>2</sub> SO <sub>4</sub> .....	0.0056	2.62
Na <sub>2</sub> CO <sub>3</sub> .....	0.0340	15.91	Mg CO <sub>3</sub> .....	0.0018	0.84
CO <sub>2</sub> .....	0.0286	13.38	Li Cl .....	trace	.....
Na <sub>2</sub> SO <sub>4</sub> .....	0.0161	7.53			
K Cl .....	0.0103	4.82		0.2137	100.00

[Gardiner River below Hot River, September 26, 1884; temperature, 13° C.]

Constituents.	Grams per kilo- gram H <sub>2</sub> O.	Per cent. of mate- rial in solution.	Constituents.	Grams per kilo- gram H <sub>2</sub> O.	Per cent. of mate- rial in solution.
Ca CO <sub>3</sub> .....	0.1873	37.94	K Cl .....	0.0200	4.00
CO <sub>2</sub> .....	0.0852	17.26	Mg CO <sub>3</sub> .....	0.0094	1.95
Mg SO <sub>4</sub> .....	0.0739	14.97	Al <sub>2</sub> O <sub>3</sub> .....	0.0019	0.38
Na <sub>2</sub> SO <sub>4</sub> .....	0.0549	11.12	Li Cl .....	trace	.....
Na Cl .....	0.0339	6.87			
Si O <sub>2</sub> .....	0.0272	5.51		0.4937	100.00

There are, however, numerons springs in the park which discharge sulphurous liquids (some of them the black ammonic sulphide (NH<sub>4</sub>)<sub>2</sub>S, very offensive in odor and donbtless fatal to fishes. Most of these springs have but a very slight discharge, and so exert no appreciable influence on the streams. The upper part of Obsidian Creek between Twin Lakes and Beaver Lake is the only running stream noticed by us as likely to prove uninhabitable by fishes. An obstacle of equal importance in the lower course of the same creek is the series of three beaver-dams, to which the existence of Beaver Lake is due; these, with their covering of brush, must be wholly impassable.

The following is a list of the species of fishes found by us in the park, with a list of the localities from which specimens of each were actually obtained :

**Catostomidæ** (Suckers).

1. *Catostomus griseus* (Girard). Gardiner River (below Mammoth Hot Springs).
2. *Catostomus ardens* Jordan & Gilbert. Witch Creek; Heart Lake.

**Cyprinidæ** (Minnows, Chubs, etc).

3. *Rhinichthys dulcis* (Girard). Gardiner River (below Mammoth Hot Springs).
4. *Agosia nubilæ* (Girard). Witch Creek; Heart Lake.
5. *Leuciscus atrarius* (Girard). Witch Creek.
6. *Leuciscus hydrophlox* (Cope). Heart Lake; Witch Creek.

**Thymallidæ** (Grayling).

7. *Thymallus signifer* Richardson. Horse-thief Spring; Madison River; Gallatin River.\*

**Salmonidæ** (Trout, etc.).

8. *Coregonus williamsoni* Girard, var. *cismontanus* Jordan. Horse thief Spring; Madison River, Gardiner River (below falls); Yellowstone River (below the falls).
9. *Salmo mykiss* Walbaum. The "Red-throated," *Cut-throat*, or "Rocky Mountain Trout." Heart Lake; Henry Lake; Howard Creek; Yellowstone Lake; Yellowstone River (above falls); Yellowstone River (at Livingston); Gardiner River (below falls); Black-tail Deer Creek; Alum Creek; Solution Creek; Riddle Lake; Cañon Creek; Madison River.
10. *Cottus bairdi* Girard, (var. *punctulatus* Gill); Gibbon River (above falls); Cañon Creek; Horse-thief Spring.

In August and September, 1889, plants of fishes were made by the U. S. Fish Commission as follows:

Eastern Brook Trout (*Salvelinus fontinalis*), in Glen Creek and in Gardiner River above the falls (5,000 fishes).

Rainbow Trout (*Salmo irideus*), in Gibbon River, above Virginia Cascades, (1,000 fishes).

Loch Leven Trout (*Salmo trutta levenensis*) in Firehole River above Keppler's Cascades (1,000 fishes).

Mountain Whitefish (*Coregonus williamsoni*). One thousand fishes in each of the Twin Lakes and in Yellowstone River below the lake.

Red-throat Trout (*Salmo mykiss*), in Lava Creek above the falls.

## THE FISHES OF THE PARK.

The following notes are those made by us on the species of fishes collected in the Park :

1. *Catostomus griseus* Girard. (*Acomus lactarius* Girard; *Catostomus retropinnis* Jordan.) (Plate VII, Fig. 1.)

This sucker is abundant in the Yellowstone and Gardiner Rivers below the falls, and numerous young specimens were taken by us in Gardiner River near the bridge below the mouth of the Hot River. No large examples were seen, but the species is said to reach a length of 18 inches.

These specimens apparently belong to the form described by Girard from the Milk River, Montana, under the name of *Acomus lactarius*. This is probably a slight variety, or perhaps it is identical with the species found in the Platte Valley, and described by Girard under the name of *Acomus griseus*. It is probable that *Catostomus retropinnis* Jordan (from the Milk River and the Platte) was based on adult specimens of *Catostomus griseus*, a species very close to *Catostomus catostomus*.

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\* Specimens not seen by us.

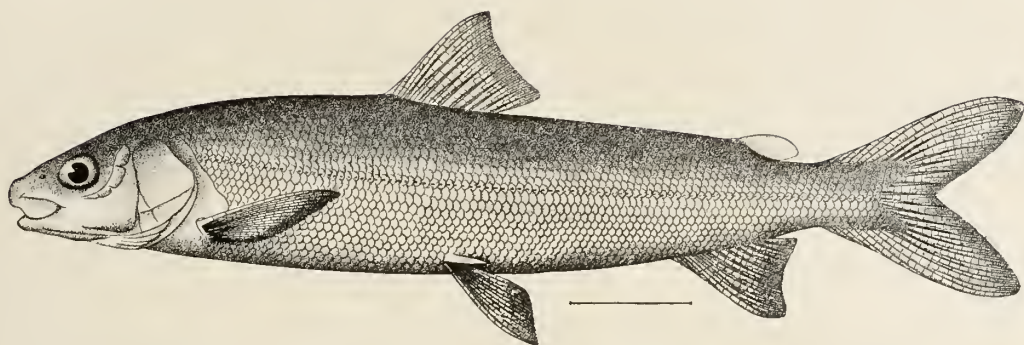


FIG. 8. MOUNTAIN WHITEFISH (*Coregonus williamsoni*, var. *cismontanus*). (See page 49.)

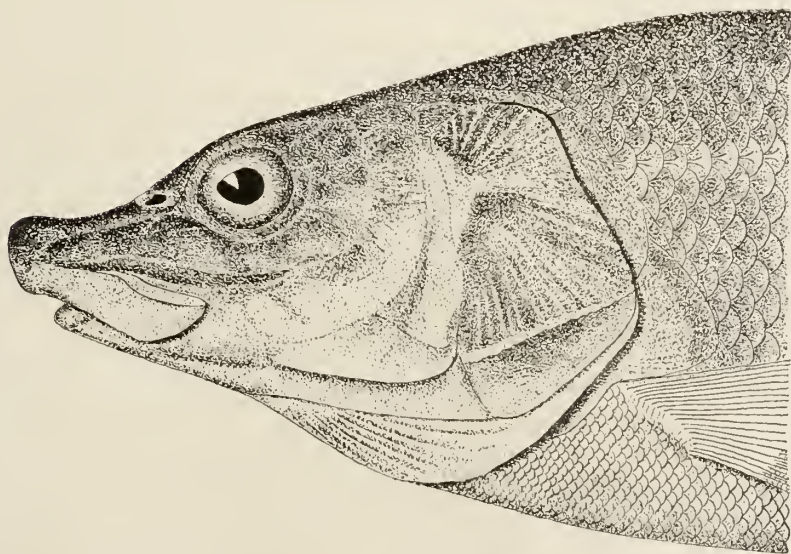


FIG. 9. MOUNTAIN WHITEFISH (*Coregonus williamsoni*, var. *cismontanus*).  
(Head of breeding male.) (See page 49.)



Compared with the young of *C. catostomus* (from Keweenaw Bay), *C. griseus* has the upper lip much thicker, with 5 or 6 instead of about 3 rows of tubercles. The lower lip is much larger in *C. griseus*, and the lower jaw has a rather distinct cutting edge. The head is larger, and the eye larger in *griseus*, and the scales on the posterior part of the body are less reduced in size. I am not sure, however, of the permanent value of any of these characters. The specimens from Gardiner River have the scales 88 to 90, while in more typical examples of *C. griseus* (from the South Platte River at Hartsell's Hot Springs and at Denver) the scales are 105 to 110. Should the difference prove constant, the specimens from the Upper Missouri region should stand as a separate variety of *Catostomus griseus lactarius*. It is not at all likely that these characters can be depended upon.

Dorsal rays 10 or 12; fontanelle well developed; color, dark gray, irregularly mottled and barred with black.

2. *Catostomus ardens* Jordan & Gilbert. (Plate VII, Fig. 2.)

Head  $3\frac{5}{6}$  to 4 in length; depth,  $4\frac{1}{4}$  to  $4\frac{1}{2}$ ; D. 2.11 to 2.13; A 7. Scales 12-70 to 72-12. Length of types, 6 to 8 inches.\*

Body moderately elongate, not strongly compressed; head broad, acutely conical, the snout short and sharp,  $2\frac{1}{3}$  to  $2\frac{1}{2}$  in head. A depression behind tip of snout, so that it forms a distinct projecting nose. Eye small,  $5\frac{1}{2}$  in head. Lower jaw rather strong, obliquely placed,  $2\frac{4}{5}$  in head. Mouth small, the lips full, the upper thick, with about 6 rows of rather coarse papillæ; lower with many rows of papillæ which are coarser in front, the lip deeply bifid: lower jaw without evident cartilaginous sheath. Interorbital space broad,  $2\frac{3}{4}$  in head. Fontanelle well developed. Scales small, crowded anteriorly, about 32 before dorsal. Fins moderate; dorsal with its free margin nearly straight, its longest rays reaching when depressed somewhat beyond the middle of the last rays, their length  $1\frac{2}{5}$  in head. Caudal moderate, well forked, the upper lobe the longer, the peduncle moderate. Pectorals long,  $1\frac{1}{8}$  in head. Ventrals and anal moderate.

Color grayish-olive above, paler below; no distinct markings; the young vaguely barred with dark olive. Very abundant in the warm waters of Witch Creek, the young also abundant in Heart Lake. The largest taken are about 8 inches in length.

This species seems to be indistinguishable from the common sucker of Utah, *Catostomus ardens*, and is quite unlike the *Catostomus macrocheilus* of the Lower Columbia. This fact, together with the general affinity of the fishes of Heart Lake with those of the Great Basin, suggests that the fauna of the Upper Snake River, above the great Shoshone Falls, may have been derived from the Great Basin rather than from the Lower Columbia. The effect of the Shoshone Falls as a barrier to the distribution of fishes is worthy of a careful investigation.

About one specimen in every three or four of *Catostomus ardens* was found to contain a long, flat, intestinal worm of unusual size, so large as much to distend the walls of the abdomen. Some of these worms were more than a foot in length, and greater than the whole abdominal viscera of the fish. The worm is apparently loose in the abdominal cavity, and can be found in every case by making an incision along the median line of the belly. The infected individuals did not appear poor or dis-

\* A much larger example, some 16 inches long, has since been sent us by Dr. S. A. Forbes. It was taken with a trammel net in Heart Lake in July, 1890. The lips seem a little fuller in the Heart Lake fishes as compared with those from Utah.

ceased. These and other worms taken by us in fishes of the Park are the subject of a special report by Prof. Edwin Linton.

3. *Rhinichthys dulcis* (Girard.) (Plate VII, Fig. 3.)

This species is common in nearly all cold clear streams in the Rocky Mountains. It is rather abundant in the Gardiner River below the falls, and it might probably be introduced to advantage in the rivers above the falls as food for trout. Our specimens agree with all others examined by us from both slopes of the Rocky Mountains in having the barbel very small and the insertion of the dorsal a little farther back than in the Eastern species, *Rhinichthys cataractæ*, midway between nostril and base of caudal. In *R. cataractæ* the insertion of the dorsal is about midway between tip of snout and base of caudal. The western form may stand as *Rhinichthys dulcis* (= *Argyreus dulcis* Girard = *Rhinichthys maxillosus* Cope = *Rhinichthys transmontanus* Cope = *Rhinichthys luteus* Garman = *Rhinichthys ocella* Garman.)

*Rhinichthys dulcis* is an active little minnow, abounding about cascades and in swift brooks. It reaches a length of about 5 inches.

4. *Agosia nubilata* (Girard). (Plate VII, Fig. 4.)

A little fish inhabiting brooks and swift waters, agreeing very closely in appearance and habits with *Rhinichthys dulcis*. It is as abundant in the Columbia basin as the other is on the eastern side. It extends its range southward to Utah, and perhaps beyond. We found this species rather common in the warm waters of Witch Creek. Scales 63 to 65; lateral line complete.

5. *Leuciscus atrarius* Girard, (Plate VIII, Fig. 5.)

I identify with Girard's *Siboma atraria* a chub which is abundant in Heart Lake and which ascends its warm tributary—Witch Creek—in great numbers, going up farther than any other fish (temperature 88°). It reaches a length of about 7 inches.\* *Cheonda caerulea*, known from a single specimen from Lost River, Oregon, may be the same also. The Witch Creek fish is less slender than Girard's type, but the probabilities are that the two are identical.

The Witch Creek fish seems to belong to the same species as the common chub of Utah (*Leuciscus atrarius*). It is a rather slenderer fish than the latter, with heavier head, lower back, and more slender tail; scales a little smaller, 11–56–6; 28 to 30 before dorsal (23 to 28 in *atrarius*). In form of mouth, eye, fins, and coloration there is no evident difference. Color dusky olive; the scales everywhere with dark points. Head 4 in length; depth  $3\frac{1}{2}$ ; teeth 2, 5, 4, 2, with rather broad grinding surface. Mouth oblique, the maxillary just reaching eye; lateral line much decurved; dorsal inserted behind ventrals; pectorals short, not nearly reaching ventrals.

The females of this species were full of eggs at the time of our visit. No worms were found in this species.

6. *Leuciscus hydrophlox* (Cope). (Plate VIII, Fig. 6.)

A few specimens, the largest about 4 inches long, were taken in Heart Lake and in Witch Creek. This species was previously known from Blackfoot Creek, Idaho,

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\* A specimen over a foot long and entirely similar to the large chubs of Utah Lake has been lately sent us by Dr. S. A. Forbes. It was taken with a trammel net in Heart Lake in July, 1890.



FIG. 10. RED-THROATED TROUT (*Salmo mykiss*). (See page 50.)

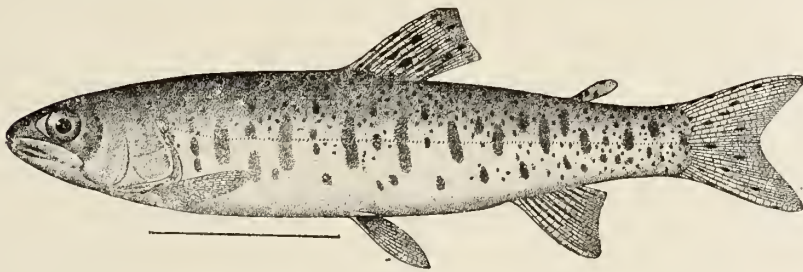


FIG. 11. RED-THROATED TROUT (*Salmo mykiss*). Young. (See page 50.)

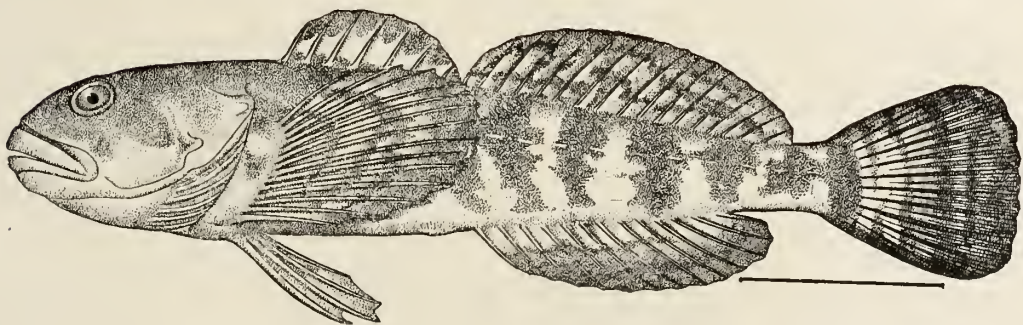


FIG. 12. MILLER'S THUMB (*Cottus bairdi*, var. *punctulatus*). (See page 53.)



which flows into the Snake River lower down. This species is allied to *Leuciscus montanus* (= *Clinostomus tania*) Cope, differing chiefly in the longer anal, sharper snout, and smaller eye. In technical characters it has much in common with *Richardsonius lateralis*, which suggests that *Richardsonius* may be a near ally of the *Clinostomus* group of the genus called *Leuciscus*.

Head,  $4\frac{1}{4}$  in length; depth,  $3\frac{1}{4}$  to 4. Anal 2, 13; lat. 1. 55. Color silvery, a plumbeous lateral band, dusted with dark points; traces of red coloration on belly in largest specimen. Lateral line much decurved. Pectoral and ventral fins long and falcate. Base of anal  $6\frac{1}{2}$  in body; lower jaw slightly projecting; upper jaw less blunt and decurved than in *L. montanus*. Eye as long as snout;  $3\frac{1}{2}$  in head (young).

7. *Coregonus williamsoni* Girard (var. *cismontanus*.) (Plate IX, Figs. 8 and 9.)

The mountain whitefish is abundant in the Madison River below the falls. It is said to be equally common in the Yellowstone River, but none were obtained by us. It is a slender and graceful fish, readily taking the fly like a grayling or trout. It is most abundant, so far as we have noticed, in the eddies or deeper places in swift streams. It seems to be essentially a river fish, rather than an inhabitant of lakes.

Comparing our specimens from Horsethief Creek, a tributary of Madison River, with others collected at Walla Walla (Washington, Captain Bendire), these specimens from the Missouri seem notably different, the body being much more slender and the fins shorter. In coloration, and in the form of the head, mouth, and eye, there is substantial agreement.

In the Madison River specimens, the depth is 5 to  $5\frac{1}{4}$  in the length, the head 5, the pectoral,  $1\frac{1}{2}$  in head, the ventral  $1\frac{4}{5}$ , the longest dorsal ray,  $1\frac{1}{2}$ , the scales, 90. In the Walla Walla fishes, the depth is  $4\frac{1}{2}$  to  $4\frac{3}{4}$ , the head  $4\frac{2}{3}$ , the pectoral  $1\frac{1}{5}$ , the ventral  $1\frac{2}{5}$ , the dorsal  $1\frac{1}{3}$ , the scales 83. Specimens from the Willamette River at Salem, Oregon, and others from Jordan River and Provo River in Utah, agree in these respects with the specimens from Walla Walla.

If these differences should prove at all constant, the Missouri River whitefish should stand as a distinct variety, *Coregonus williamsoni cismontanus*. The type of *Coregonus conesi* Milner, is from Chief Mountain Lake, Montana, a tributary to the Saskatchewan on the east side of the Divide. This specimen, lately examined by me, shows the prolonged snout characteristic of the males in the breeding season. In all respects, so far as I can see, it agrees with the typical form of *Coregonus williamsoni* and not with the variety found in the Park. Its scales are 84; the pectoral is  $1\frac{1}{5}$  in the head,  $5\frac{1}{2}$  in the body; the ventrals are  $1\frac{1}{3}$  in head. The depth  $4\frac{1}{2}$  in length; the dorsal is broken. *C. williamsoni* much resembles *C. quadrilateralis*, but the latter has a smaller mouth and the gill-rakers notably shorter and thicker.

8. *Thymallus signifer* Richardson. (Var. *ontariensis*.) (Plate VIII, Fig. 7.)

The Grayling is very abundant in the Madison River below the junction of the Firehole and the Gibbon. Numerous specimens were collected for us in Horse Thief Spring, a small stream just outside the limits of the Park, by Mr. Lucas. The grayling is said to ascend the river in summer as far as the Firehole Falls and Gibbon Falls. It is said also to be found in the Gallatin River, in the northwestern part of the Park.

We have carefully compared our specimens with others collected by Judge D. D. Banta, in Otter Creek, in the Keweenaw Peninsula, and with a specimen from Au Sable

River, in the southern peninsula of Michigan. The first-named locality, by the way, is one not generally known and not previously recorded. The occurrence of Grayling in the northern peninsula of Michigan is even disputed by anglers.

The differences noted by Mr. Milner as distinguishing the Montana fish (as *Thymallus montanus* Milner) do not seem to be constant. The Montana specimens are not deeper than the others (depth  $5\frac{1}{4}$ ), and in the number of the scales (98) they agree with the Otter Creek specimens. The Au Sable specimen has 93 scales. The dorsal rays are 21 or 22 in Michigan specimens, 19 in those from Montana. The only differences evident are in the color of the dorsal fin. This is alike in all the Montana specimens, but its peculiarities may be due to difference of season. In the Montana examples (in alcohol) the fin is largely dusky green. Its posterior part has three or four rows of bright orange-brown spots, faintly ocellated, irregular in position, some of the spots oblong and obliquely placed. Above this is one regular row of similar spots, extending obliquely across the fin from the end of the second third of the anterior rays to the tip of the last ray. Fin edged above with the same bright orange-brown.

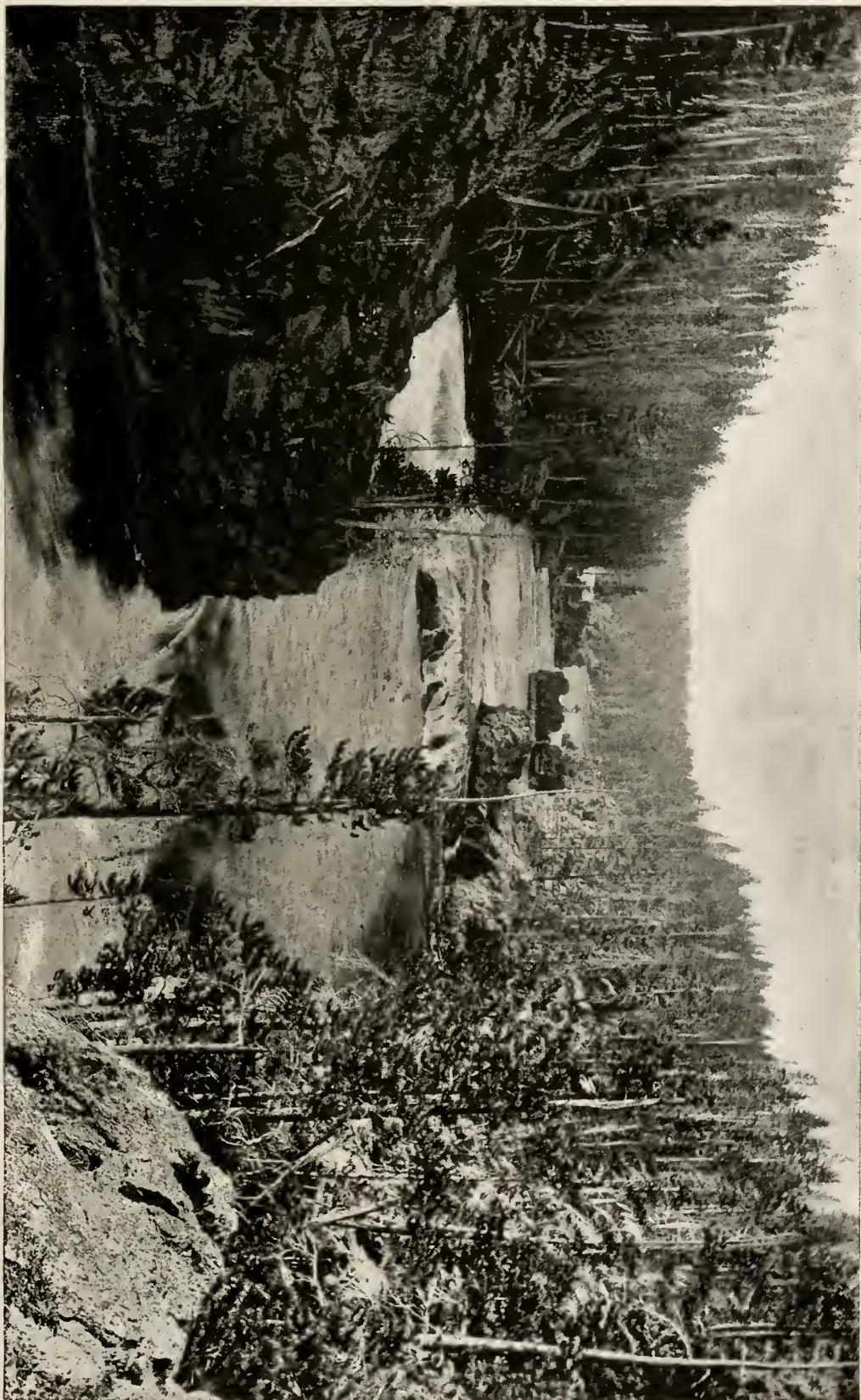
I have no specimens of the true northern *signifer*, but taking the figure published in the Natural History of Aquatic Animals, plate 195, as a basis of comparison, the grayling of Montana and Michigan may differ in the lower and less spotted dorsal and the slightly smaller scales (98 instead of about 92). Should these differences hold, it will stand as *Thymallus signifer ontariensis* (= *T. tricolor* Cope = *T. montanus* Milner).

9. *Salmo mykiss* Walbaum. The Red-Throated or Rocky Mountain Trout. (*Salmo purpuratus* Pallas: *Salmo stellatus*, *clarkei*, *virginalis*, *lewisi*, etc., of authors). (Plate X, Figs. 10 and 11.)

I have compared a large series of trout from the Park with trout from various other streams in the Rocky Mountain region. There seems to be no doubt that all the trout in the Park belong to a single species, and that this species is identical with the common red-throated or black-spotted trout of the Lower Columbia, and of the coast rivers from Oregon to Kamtschatka. This species was first mentioned by Steller under its Russian name of *mykiss*. Later it received the binomial names—*Salmo mykiss* Walbaum, 1792, *Salmo muikisi* Bloch & Schneider, 1801, and *Salmo purpuratus* Pallas, 1811. Probably all the trout of the Rocky Mountain region belong to this single species, but certain marked varieties of it occur in waters of Colorado, of which a detailed discussion is given in another paper.

The trout of Yellowstone Lake seem to differ from those of Heart Lake and Henry's Lake in having the black spots larger and more distinct and rather less numerous. In these respects very much individual variation is shown. The trout from Heart Lake and from Henry's Lake are essentially like others from Walla Walla in this regard, and those from the Yellowstone below the falls have the spots generally smaller than in those from the lake. The trout of the Upper Missouri region have received the name of *Salmo lewisi* Girard, but I can not recognize *S. lewisi* as even varietally distinct from *S. mykiss*. In fact, as elsewhere stated in this paper, there is good reason to believe that the Yellowstone Lake was stocked originally from Snake River, through Pacific Creek, Two-Ocean Pass, and Atlantic Creek. It is, moreover, not unlikely that an interchange of individuals still occasionally takes place across the Continental Divide.

The trout of the Yellowstone Lake and of many of its tributaries above the falls are infested by a parasitic worm (*Dibothrium cordiceps* Leidy). Of the specimens ex-



YELLOWSTONE RIVER; RAPIDS ABOVE THE UPPER FALLS. (See page 34.)



UPPER FALLS OF THE YELLOWSTONE RIVER. (See page 54.)







LOWER OR GREAT FALLS OF THE YELLOWSTONE RIVER. (See page 54.)



amined by us from the Yellowstone, between the falls and the Lake, all showed some traces of the presence of the worm. These were first noticed by us as small whitish cysts, about as large as a grain of wheat, around the pyloric cœca, sometimes in the ovary. These cysts contain small worms, apparently similar to the larger ones. These larger worms, from 1 to 5 inches in length, are found in the liver, in the abdominal cavity, or in the muscular substance of the belly or sides. When worms exist in the flesh they can usually be found by skinning, as the flesh about them is more or less diseased. These facts may perhaps be better appreciated by the following notes on specimens examined:

Female (dissected) from Yellowstone River (taken like the next four in the eddy at the bend of the river, about  $1\frac{1}{2}$  miles above the Giant's Caldron and Mud Geyser). A worm 10 inches in length, in a sac along the intestine; another worm about 4 inches long, in a sack, in the muscle of the abdominal wall, the flesh pale and diseased for an inch about the worm. Ovaries full of little worm cysts, and imperfectly developed. Numerous cysts among the pyloric cœca in this and all other diseased specimens.

A large male (No. 137): Liver, pyloric cœca, and spleen with worms; the worm in liver large. Testes wholly empty and shrunken. Had external appearance of a female trout.

Male (421): No worms evident, except a few cysts about the stomach; testes full and normal.

Female; No worms evident; ovaries large and full of normal eggs; cysts present among the pyloric cœca in this and all other specimens from Yellowstone River.

Male (285); Pyloric cœca full of cysts.

Males (323, 244); Worms present; sexual organs little developed.

Nos. 3 and 4, Riddle Lake. Viscera normal; no trace of worms or cysts.

Female (494); from Heart Lake, at mouth of Witch Creek; intestines and cœca with cysts and with some small worms. Other worm-like parasites of other genera in cavity of mouth and on dorsal fin.

Young male (365); Heart Lake: a single small encysted worm among the pyloric cœca; no others evident.

A basket of dressed trout, taken in the Yellowstone River at Livingston was examined. Among these was one worm 3 inches long, apparently of the same species as the others. Numerous other specimens were examined without developing any facts other than those included below.

I offer the following generalizations with much hesitation, as I know practically nothing of the life-history of intestinal worms of the group to which *Dibothrium* belongs.

Worms are found more or less abundant in nine-tenths or more of the grown trout in the Yellowstone Lake, and its larger tributaries, and in the Yellowstone River as far as the Lower or Great Falls. The trout in the upper Yellowstone are likewise affected, those in Bridger's Lake being (according to Mr. Arnold Hagne) largely wormy, as also those in Atlantic Creek (Elwood Hofer). The small trout (under 6 inches) have not been found to contain worms.

Worms are popularly believed not to exist in the Lower Yellowstone (below the falls). The discovery of a worm at Livingston would contradict this. Perhaps worms exist, but are small or scarce. Those in the encysted condition would hardly attract popular notice, for ordinary observers do not even distinguish the worms from the pyloric cœca.

Worms certainly exist in the trout of Heart Lake, to all appearance identical specifically with those in Yellowstone Lake. This lake is on the west side of the Divide and is drained by Snake River. It has at present no connection with Yellowstone Lake.

Yellowstone Lake and Heart Lake have one feature in common, and one shared by no other lakes containing trout with which I am acquainted (Shoshone and Lewis Lakes being destitute of fishes). Both have a large influx of hot water from geysers and from hot springs, some of them outside the lake, but many of them opening under the water. This suggests the theory that the existence of the worm itself, or perhaps its malignity as a parasite, is dependent on the presence of hot water, instead of the cold waters ordinarily frequented by trout.

As bearing on this suggestion I may notice: In both lakes the trout actually frequent the warm waters, attracted apparently by the great abundance of fish food to be found there. It is perhaps not impossible that with the great variety of insect, crustacean, and worm life, the germ of the worm may occur also. The streams in which wormy trout occur, so far as known, are all in easy access from Yellowstone Lake. Riddle Lake, although tributary to the Yellowstone, has an outlet long, narrow and tortuous, being dry at both ends in the summer. It is so difficult of access that probably trout do not often ascend it. Only young trout were seen in the creek, and the trout found in the cold waters of Riddle Lake showed no sign of worms. The trout in Pelican Lake and other waters to the east of Yellowstone Lake and tributary to it are said to be infested with worms. These lakes receive much water from Hot Springs.

Connected with this fact of the development of worms in warm waters is the fact that the suckers in the warm (largely geyser) waters of Witch Creek (*Catostomus ardens*) are afflicted with another parasitic worm. I know nothing of the history or relationships of this worm, but it is hard to avoid the supposition that the warm water favors its development. Although the sucker is a small fish, the worm infesting it is larger than any other parasitic worm I have ever noticed among fishes, and, as elsewhere stated, it often occupies more space in the abdomen of the fishes than do the fish's own viscera.

The lakes of Washington, Colorado and Utah, abounding in trout of the same species, show, as far as we know, neither geyser water nor *Dibothrium*.

It will be interesting to know whether the trout introduced into Lakes Shoshone and Lewis, both of them with similar hot tributaries, will be afflicted with worms. It will also be interesting to know whether any other species of trout will show immunity from them. Possibly an abundance of other fishes as food for trout would draw them away from the hot waters, and free them from worms.

The "wormy" trout are leaner and more compressed than others, and the sides of the belly are likely to show ridges and lumps. The flesh is said to be redder in the diseased fish, and the external color is more likely to be dusky or brassy.

In the trout examined the presence of many worms was accompanied by a shrunk or irregular condition of the ovaries or testes. Perhaps spent fish are more likely to be wormy. According to Mr. Arnold Hague, the best trout are in swift or deep waters; the wormy ones about eddies or among logs or masses of floating vegetation. The wormy trout takes the fly freely but is in general little gamey. In fact, all the Yellowstone trout seem less active than is usual for the species.

The value of these attempts at generalization can only be determined by the thorough study of some competent helminthologist in the field. The life-history of the worms is yet to be made known. When this is done possible remedies may be suggested. The probabilities are that the trout and the worm will never be divorced in Yellowstone Lake.



CRYSTAL FALLS OF CASCADE CREEK. (See page 55.)



It is said the bears are often seen going about the shores of the lake picking up the dead fish.

10. *Cottus bairdi* Girard. (Var. *punctulatus*.) (Plate X, Fig. 12.)

The "Miller's thumb" or "blob" is found in great abundance in the grassy bottoms of Madison River, Gibbon River, and Cañon Creek. In Gibbon River it is found above the falls as well as below it, an anomaly of distribution as yet unexplained, unless we call in the aid of the Osprey or some similar agency. It is said that the species is found also in the Yellowstone below the Park.

The specimens taken by us in the Gibbon and Cañon Creeks, as well as those procured by Mr. Lucas in Horsethief Spring are identical with specimens taken by us from Eagle River, Colorado, and in other tributaries of the Colorado. All of them belong to the variety or species named *Potamocottus punctulatus* Gill, although the dark spots are generally coarser and more diffuse than is shown in Professor Gill's figure.\*

In the specimens from the Park the band of palatine teeth is broad; there are no prickles on the skin. The head is  $3\frac{1}{2}$  in length and the rays are D. VII-17; A. 13; V. I, 4.

Comparing these with specimens (*Cottus bairdi carolineæ*), from Mammoth Spring, Missouri, the differences seem well marked. Var. *punctulatus* has the head blunter, lower and more rounded, the cheeks more tumid and the top of the head without median longitudinal depression. Var. *carolineæ* has the axil prickly, the outline of the head angular, the top of head with a median longitudinal depression from snout to nape, and the body has broad distinct black cross-bars.

These two forms seem like distinct species, but other specimens are intermediate; specimens from Torch Lake, Michigan, agree with *punctulatus* in color, and are intermediate in form; specimens from White River, Indiana, are colored like var. *carolineæ*, but are intermediate in form. Apparently *punctulatus* should be recognized as a subspecies but its range and distinctive characters are yet to be made out in detail.

## THE STREAMS AND LAKES OF THE PARK.

The following is the substance of our field-notes on the physical characteristics of the streams and lakes of the Park:

### YELLOWSTONE BASIN.

**THE YELLOWSTONE RIVER.**—The Yellowstone River drains an area of 1,900 square miles, or about half the surface of the Park. It has its rise in the Continental Divide, to the southeastern limit of the Park. One of its tributaries, Atlantic Creek, flows to the eastward by the side of a low part of the Divide, known as Two-Ocean Pass. On the opposite side of this pass, at a distance of about one-eighth mile, flows Pacific Creek, in the opposite direction, though parallel with Atlantic Creek. Pacific Creek is a tributary of Snake river. The Divide between the Yellowstone and Snake River is a marshy meadow, more or less overflowed in spring, its whole width scarcely more than an eighth of a mile. It is supposed that the stock of trout in the Yellowstone, above the falls, must have originally come from Pacific Creek. Whether the lower Yellowstone and the upper waters of the tributaries of the Missouri were stocked in this way is less certain. If the trout of the Missouri came across Two-Ocean Pass

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\* Ichthyology Captain Simpson's Rept. Expl. Basin of Utah.

the whitefish might have done so also; but this is unlikely, as no whitefish are now in Yellowstone Lake nor in Yellowstone River above the falls. The Yellowstone is a very clear, cold stream (temperature  $50^{\circ}$  to  $60^{\circ}$ ), and, taking its whole extent, it is one of the most picturesque in America. It flows through a large glacial depression in which it expands to form the Yellowstone Lake (7,741 feet elevation). This is a large body of water, of very irregular form, which is often compared to that of an uncouth hand with a very large thumb and three shrunken fingers. Its greatest length, north and south, is about 22 miles, and its greatest width across the thumb is about 15. West and south of the lake are high mountains, and the lake banks are, in many places, bold and rocky, the hills being covered with pine and fir trees. Toward the north end of the lake the banks are lower, and here terraces show previous greater extension, covering the marshy pastures and woodlands of its outlet, the territory known as Hayden Valley.

Above the lake the Yellowstone River winds through marshy meadows, between wooded hills, behind which are the rugged peaks of high volcanic mountains. The current is sluggish above the lake, and between the lake and the upper falls there is also no great descent. The river below the lake is bordered by low hills, some of them wooded, others forming open grassy pastures. Below the lake the large river flows for about 15 miles with a quiet current, then plunges into a deep cañon over two vertical falls 109 feet and 308 feet in height (see plates XI, XII, XIII). This famous cañon, which needs no description here, is more than 20 miles long, with nearly perpendicular walls, 800 to 1,100 feet in height. The current of the stream below the falls is swift until it leaves the Park. The Yellowstone retains its general character as a clear, cold, and swift river for almost its whole course through Montana until it joins the Missouri. Trout abound throughout from the source of the river in the mountains as far as Livingston, and doubtless for many miles beyond. Above the falls the river contains no other kind of fish. The abundance of trout above the falls is remarkable. In one eddy in the river, eleven, averaging  $1\frac{1}{2}$  pounds each, were seen together, and in parts of the lake they are as numerous as in the river. They are everywhere eager to take the fly, but they are regarded as indifferent fighters in comparison with the trout of other streams.

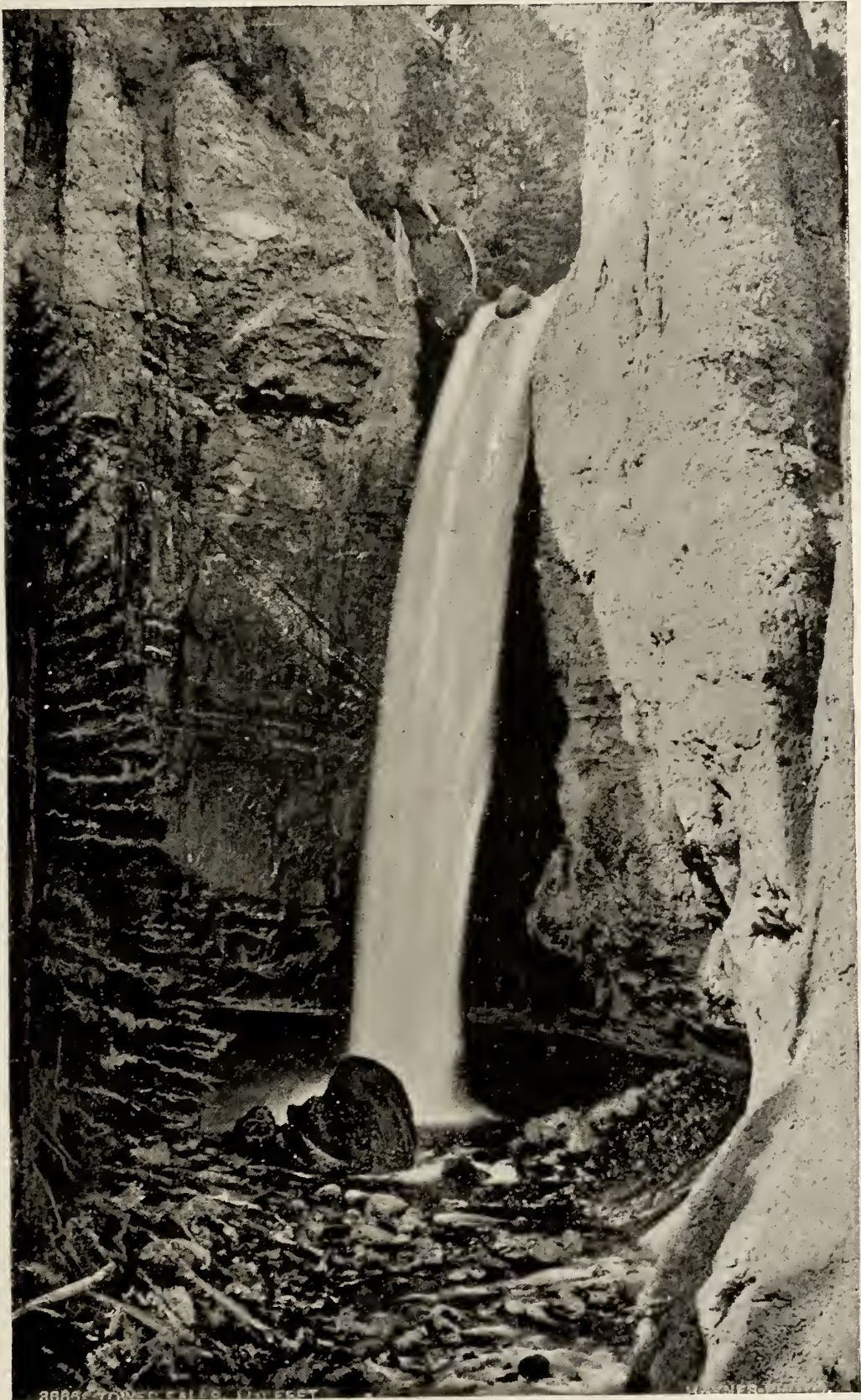
In Yellowstone River, and in most parts of the lake, fish-food, such as insects, crustacea, larvæ, etc., are very abundant. The stomach of one trout taken in the river contained helgramites (larvæ of *Corydalus*), grasshoppers, and caddis-worms.

Of the tributaries of the Upper Yellowstone, none were visited by us. Common report says that all are well stocked with trout, and that the trout in all or most of them are wormy.

The following tributaries of the lake were examined:

*Solution Creek* is a small, narrow stream, with lava bottom and grassy banks lined with willows. At the time of our visit it was dry for 2 or 3 miles above its mouth, and for about the same distance below its source in Riddle Lake. In the standing pools of its middle course were numerous young trout.

*Riddle Lake* (so called because of the mystery of its outlet, "solved" by the discovery of the little creek) is a clear pond of roundish outline about  $1\frac{1}{2}$  miles in diameter. About its outlet are numerous lily-pads and other plants. Its shores are shallow, and its bottom chiefly lava gravel. Trout seem to be numerous in the pond. Two were taken, one a female with full ovaries, the other a male with shrunken testes.



TOWER FALLS OF TOWER CREEK. (See page 56.)



Both seemed to be free from worms. There is no evidence of hot-water action in Riddle Lake. The temperature of the lake is about 50°.

*Bridge Bay Creek* is a small brook of no importance.

*Arnica Creek* is a similar stream, the water of which is warmed by hot springs. No trout were seen there.

*Trout Creek* is a clear stream with grassy banks and gravel bottom. Water clear and clean, about 58°. Its course lying chiefly in Hayden Valley it has no falls. No fish were seen, although it is said to be a fair trout stream but inferior to the next.

Both of these enter the Yellowstone River from the west some 12 miles below the lake.

*Alum Creek* is a clear stream about 8 feet wide and 1 or 2 feet deep, rising in the Continental Divide opposite the head of Nez Percé Creek and flowing eastward through the grassy fields of Hayden Valley. Its bed contains much white alkali from the hot springs above and there is a perceptible alkaline taste to the water. Its temperature is about 60°. In its upper course it has some hot tributaries, one of these, Violet Creek, with a number of hot springs and mud-holes. Still another fork is charged with alum. A third branch is said to be one of the best trout streams in the park. One small trout was noticed while fording this stream, a fact which tends to show that alkaline and warm waters are not specially avoided by trout.

*Sour Creek*, a large stream, entering the river opposite Alum Creek, was not examined nor was the cause or degree of its sourness made out.

*Cascade Creek*, a clear brook about 3 feet wide, enters the Yellowstone between the falls. The high, nearly vertical "Crystal Falls" (129 feet) is near the mouth of the stream and, of course, prevents the ascent of fishes (see plate XIV). It is said that fifty trout from the Yellowstone were placed in Crystal Lake, a pond toward the head of this stream, last spring by Mr. Cummings. The planting of Yellowstone trout in streams without trout has been since forbidden on account of the danger of the spread of the parasitic worm.

*Sulphur Creek*, a small clear stream having in its course numerous sulphur springs and boiling sulphur holes, flows into the grand cañon. It has, of course, no fish. Another small stream, Surface Creek, with a very high cascade, "Silver Cord," flows into the cañon from the opposite side.

*Lamar River*, or east fork of the Yellowstone, is a large stream, flowing into the Yellowstone from the east at a point below its cañon.

This is well stocked with fish, as are its tributaries, the chief of which are Slough Creek and Soda Butte Creek. These streams were seen by us only from a distance. At Baronette's Bridge, at the mouth of Lamar River, a trout was taken which weighed 4 pounds 4 ounces, when dressed. It was 16 inches long.

*Slough Creek* is said to be well stocked with fishes up to the lakes at its head which is near the mining camp of Cooke City, Mont. One of these lakes is said to be without trout on account of the presence of much iron in its outlet, so much that the bottom is red. Another has no trout but multitudes of "blob" (*Cottus bairdi punctulatus*). This stream has a small water-fall in its outlet. Still another, "Lake Abundance," is said to be full of trout.

*Soda Butte Creek* is well stocked with fish except in its upper part where a water-fall keeps them back.

*Hellroaring Creek* flows into the Yellowstone from the north below the mouth of

Lamar River. Its lower part is well stocked with fish. The upper part is almost unknown. Its rise is seen to be in high granite mountains, and in its course there are probably numerous cascades. According to Gannett "it comes from the granite portion of the range north of the Park, cutting a tremendous gorge through it." At the foot of the gorge is a sharp conical peak of granite known as Hellroaring Mountain.

*Crevice Gulch*, the next stream on the right bank, is beyond the limits of the Park. It is said to contain both trout and whitefish.

*Antelope Creek*, on the left bank, is a small stream flowing down a grassy slope on the south side of Mount Washburn. This stream has no cañon and no distinct cascade and is fairly stocked with fish.

*Tower Creek* is a larger stream, draining the semi-circle of mountains of which Mount Washburn is the highest, a group, according to Gannett, comprising twenty-five summits ranging in height from 9,000 to 10,400 feet. The current of Tower Creek is swift and for almost its whole length the stream is hidden in dense forests. It is, perhaps, the coldest stream in the Park (about 45°). About one-fourth mile from its mouth (at which point this stream is separated by a narrow lava ridge from Antelope Creek) Tower Creek forms a singularly picturesque fall of 132 feet (see plate XV). This fall is quite vertical and it is surrounded by lofty pillars or towers of volcanic conglomerate. Below the fall is a deep and narrow cañon. The stream is here some 10 feet wide by 1 deep. There are no fish above the falls but for those species of trout which are especially fond of cold and shade no better stream exists in the Park.

*Lost, Elk, Geode and Oxbow Creeks* are small streams—too small to be of consequence for fish. Although having a large bed Oxbow Creek was entirely dry in October and the other streams had little water.

*Black-tail Deer Creek* is a clear, rather cold stream (55°) running largely through open pastures, with willows along its course. It has no cañon or falls. Its bottom is of lava gravel and rocks with some weeds. It is 5 or 6 feet wide by 1 or 2 deep, and is well stocked with trout. Young trout were seen in the little pool at the bridge, but no minnows.

*Lava Creek* or East Fork of the Gardiner River, is a clear mountain stream resembling Tower Creek, and like the latter flowing chiefly through evergreen forests on the north side of the mountain range. The stream is about 10 feet wide by 1 or 2 deep. Towards its mouth it cuts its way into a broad, flat shelf of lava, forming two successive cataracts about one-tenth of a mile apart. The upper falls, called Undine Falls, is vertical for about 30 feet, then with two additional leaps of about 20 and 10 feet (see plate XVI). The lower fall is vertical and about 50 feet high. Below this fall the stream flows through a highly picturesque cañon joining the Gardiner River, above Mammoth Hot Springs. In this cañon trout are abundant.

*Lupine Creek* is a small tributary of Lava Creek entering it above the falls. This stream has a high cascade (Wraith Fall), about 100 feet high.

Notwithstanding the barrier offered by Undine Falls, it is said, on good authority, that small trout have been seen in Lupine Creek below Wraith Fall (Elwood Hofer) and trout have been taken in Lava Creek above the falls. This raises the question as to how they came there. Our attention was called by Mr. Hofer, to the way in which trout may have crossed the Divide from Black-tail Deer Creek to Lava Creek.



UNDINE FALLS OF LAVA CREEK. (See page 56.)



The easternmost tributary of Lava Creek is a grassy slough with very little current. The narrow stream in its midst is nearly dry in summer. The same conditions extend to the summit of the Divide, which rises to the height of about 3 feet above a small pond with which the slough begins. The Divide is a rod or two across at its lowest part near the pond. On the east side of it, but lower down, is a similar pond with grassy surroundings, which flows into Black-tail Deer Creek. Into both these depressions considerable springs flow, especially into the one on the west.

The grassy slough first named, tributary to the Lupine Creek, has very little slope for a mile or more. Should its waters rise in spring so that the almost dry pond would be 3 feet in depth, this pond would overflow on both sides, and a continuous water-way would be made from Lupine Creek down into Black-tail Deer Creek. This water-course would be shallow, and is doubtless seldom traversed by fishes. It is, however, a possible one, and serves to account for the presence of trout in Lava and Lupine Creeks.

By order of the U. S. Fish Commissioner other trout from Howard Creek have this year been placed above the falls in Lava Creek.

*Gardiner River* (or *Middle Gardiner*) rises in the east slope of the Gallatin Mountains in the northwestern part of the Park. It flows eastward, southeastward, then abruptly northward, bending around Bunsen's Peak, and forming a deep cañon, toward the head of which is the large Osprey Falls (see plate XVII). Gardiner Cañon is some 800 to 1,000 feet deep, with vertical walls of lava, basalt, etc., and in grandeur is surpassed only by the Cañon of the Yellowstone. The Osprey Falls is about 150 feet high, and nearly vertical.

Trout are abundant in the river from the foot of the fall to its junction with the Yellowstone, some 4 or 5 miles below. No fishes have been seen in the Gardiner or any of its tributaries above the Osprey Falls except the brook trout (*Salvelinus fontinalis*), lately planted at the bridge below the mouth of Indian Creek.

Above the falls Gardiner River is a clear, cold stream (about 50°), with numerous stones, boulders, and deep holes. It is well provided with fish food.

Its principal tributaries above the falls are Obsidian Creek and Indian Creek, the latter coming in from the southwest, the former from the south. The largest of these, Obsidian Creek, heads in or near the Twin Lakes. There are two small ponds about one-half mile and 1 mile long, with no visible inlet, the small stream connecting them being dry in summer. The lower and smaller pond is said (by Mr. Lucas) to have large alum springs near its outlet, the water being so charged with alum that horses will not drink it. The outlet, Obsidian Creek, is at first very small, and its course for 2 or 3 miles is full of hot springs, solfataras, boiling mud-holes, and various similar heated areas offensive to fish. It is not likely that a fish could pass through this stream, except in very high water.

Lower down cold springs enter the stream, and at Beaver Lake the water is clear and cold. Beaver Lake is a shallow grassy pond, about a mile long, formed by the beavers. Three large beaver dams cross it, and each of these dams in ordinary seasons would be likely to block the ascent of fishes (see plate XVIII). The lower one especially is covered with brush, over which fishes could not leap. Below this lake Obsidian Creek receives the clear, cold waters of Winter Creek, a large stream which heads in Christmas Tree Park, at the foot of Mt. Holmes. The stream now flows through Willow Park, a large mountain meadow, in which it joins the Gardiner River.

Obsidian Creek with Winter Creek will, apparently, be one of the best of trout streams. Its temperature is about 50°. Its bottom of lava gravel is lined with grass, algae, and water plants in which small crustacea swarm.

*Indian Creek* is a clear, cold stream, similar to the Gardiner, and like it, heading in the east slope of the Gallatin Mountains.

*Glen Creek*, or West Fork of the Gardiner, rises in Sepulchre Mountain and flows southeast, then northeast, joining the Gardiner at the foot of its cañon.

This is a small stream, which runs mostly through open meadows. It is 5 or 6 feet wide and 1 to 2 feet deep, with gravelly and grassy bottom. Its waters are very cold (about 48°) and full of crustacean life. The red-bellied frog, *Rana septentrionalis*, is abundant. Glen Creek has a high waterfall, some 70 feet high (Rustic Falls), at the "Golden Gate," near the base of Bunsen's Peak (see plate VIII).

Below the fall the deep cañon is so choked up with boulders and talus that fish can not ascend it. Above the fall Glen Creek receives a considerable tributary, which drains Swan Lake. Swan Lake is a small roundish pond, about half a mile long, with a bottom of crumbled lava. While its shores are very shallow, the depth in the center seems considerable. The waters are clear and cold, abounding in insects and crustacea. In Glen Creek and the Gardiner River 5,000 Brook trout, *Salvelinus fontinalis*, were placed in August of this year.

The lower course of the Gardiner, below the three falls (Osprey, Undine, and Rustic), is well stocked with trout and contains whitefish (*Coregonus williamsoni*), suckers (*Catostomus griseus*), and minnows (*Rhinichthys dulcis*). Below Mammoth Hot Springs it receives the scalding Hot River, the drainage of the springs. That these hot calcareous and sulphuretted waters are not destructive to fish life, even to that of trout, has been already shown. It is said that in winter the trout are especially abundant about the mouth of this stream.

#### MISSOURI DRAINAGE (730 square miles).

The three streams which unite near Gallatin City, Mont., to form the Missouri are the Jefferson, the Madison, and the Gallatin Rivers. Of these, the Jefferson lies outside the Park. The Gallatin and two little-known tributaries (Fan Creek and Grayling Creek) rise in the wild region west of the Gallatin Mountains in the north-west corner of the Park. These cold, clear streams, rarely visited by sportsmen, are said to be well-stocked with trout and grayling.

*Madison River* drains an area of 730 square miles in the Park; this includes the country to the west of the Yellowstone and to the north of the Continental Divide. The name Madison is only used for the river below the junction of its chief tributaries, the Firehole River and the Gibbon River.

*Gibbon River*, the smaller of the two streams, rises north of the center of the Park in the hills and marshes around Grebe Lake, a body of water not far from Crystal Lake, on Cascade Creek. Grebe Lake, about a mile long, surrounded by mountain meadows, is said (by Mr. Hague) to be one of the finest lakes in the Park. In the outlet of the lake above the falls known as Virginia Cascades, 1,000 rainbow trout (*Salmo irideus*) have been lately planted. The region about the upper course of the Gibbon is heavily timbered and its basin is separated by low divides from that of Obsidian Creek. Notwithstanding the influx of many hot springs, solfataras, soda springs, and even iron springs, the Gibbon remains a clear, cold river (55°) throughout its course. The Vir-

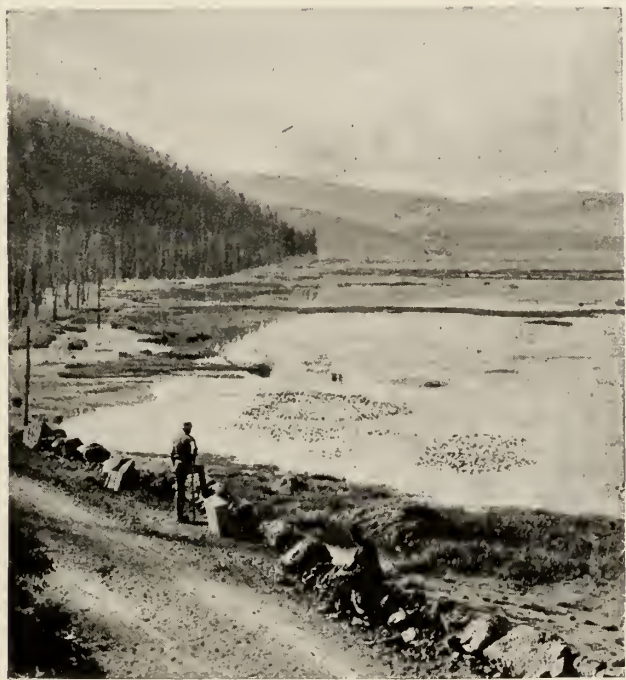


OSPREY FALLS OF GARDINER RIVER. (See page 57.)





RUSTIC FALLS OF GLEN CREEK. (See page 58.)



BEAVER LAKE; SHOWING BEAVER DAMS. (See page 57.)



ginia Cascade (some 60 feet high) will probably prevent the ascent of fish (see plate XIX). Below these cascades is the open valley of the Norris Geyser Basin, and still lower a broad meadow known as Elk Park. Several miles below Elk Park in a narrow cañon is the Gibbon Falls (80 feet high), a picturesque cataract, which trout certainly can not ascend (see plate XX). Above this fall are no trout, but an abundance of blob, or miller's thumb (*Cottus bairdi punctulatus*), and it is not easy to explain how they come to be there. Below the falls trout are abundant and, as in the Madison, grayling are said to be found.

*Cañon Creek*, a small clear stream, very cold and with grassy bottom, joins the Gibbon River below the falls. This stream flows through steep pastures, without falls except near its source. It is 6 to 8 feet wide and 1 to 3 feet deep, and is well stocked with trout. In this stream the blob is very abundant, absolutely swarming in the grass.

*Firehole River*, about twice the size of Gibbon River, joins it from the south. "This stream heads just west of Shoshone Lake, separated from it and from the head of Bechler River by relatively low divides" (Gannett). It flows through a small lake nearly dry in summer (Madison Lake), below which it receives a fine clear tributary from the east (Spring Creek). Along Firehole River are the most noteworthy of the geyser basins, and a great volume of hot water is poured into it without, however, rendering its waters at any point really warm, the average being probably 55° to 60°.

In its upper course, the Firehole, like the Spring Creek, is a clear and very cold stream flowing through dense woods, with narrow marshy valleys, alternating with small cañons. In this part of the stream 1,000 Loch Leven trout (*Salmo trutta levenensis*) were planted in September, 1889. Keppler's Cascades, above the upper geyser basin is a series of three or four very picturesque falls, some of them probably impassable to trout (see plate XXI). In the upper geyser basin the Firehole River receives the drainage of a multitude of hot springs, besides two considerable streams, also of mixed cold and hot water, the Iron Spring Creek and the Little Firehole River. The stream is here very clear. It is full of plants and other organisms, and its waters have a taste of decayed vegetation. Even at the midway geyser basin the stream is probably not too warm for trout. At the lower basin the Firehole receives the waters of Sentinel Creek, Fairy Creek, and the larger Nez Percé Creek. The latter, which comes in from the east, is nearly half as large as the Firehole and similar as to character and temperature of the water. It is fed by numerous short streams, some of them hot, and most of them confined to a narrow cañon. Some five miles below the mouth of the Nez Percé the Firehole, now a large river 2 to 3 rods wide and 2 to 5 feet deep, enters a wild cañon with banks of rough lava. In this cañon are the imposing falls of the Firehole, about 60 feet in height (see plate XXII), and forming an effective barrier to the ascent of fishes. Below this falls the common fishes of the Madison River, trout, whitefish, grayling, and blob, are said to be abundant. Lower down on the Madison River collections were made by Mr. E. R. Lucas, and a series of specimens given to us with the following notes:

"On October 2, I collected from Horsethief Spring 2,000 whitefish, which I planted next day in the Twin Lakes. Horsethief Spring heads in the Divide in Montana and flows 1½ miles, emptying into the North Fork of the Madison River. The first half mile of this stream is of a rocky bottom, with no growth of moss or grass. The second half mile is of white sandy bottom, completely filled with a growth of moss and some

grass. This moss is alive with fish food (specimens of which were sent). On October 15, I collected 1,000 more whitefish and planted them in Yellowstone River, above the falls. There are unlimited numbers of these whitefish in Horsethief Spring, running in size from 2 to 5 inches. There are also quite a large number of grayling in the stream."

Besides the grayling and whitefish, numerous specimens of the blob were taken in Horsethief Spring.

COLUMBIA RIVER DRAINAGE (682 square miles).

*The Snake River*, the largest tributary of the Columbia, drains that part of the Park (nearly one-fourth of the whole area) which lies to the southwest of the Continental Divide. This large territory is chiefly a densely wooded plateau and contains three large lakes, Shoshone, Lewis, and Heart, the largest lakes in the Park, next to the Yellowstone. Two of these lakes, with their tributary streams, are without fish, but the other rivers, Snake, Heart, Falls, and Bechler, are said to abound in trout except in certain of the headwaters where their ascent is prevented by water-falls (see plate XXI). As only a small part of this region was visited by us, I shall speak of the waters actually examined.

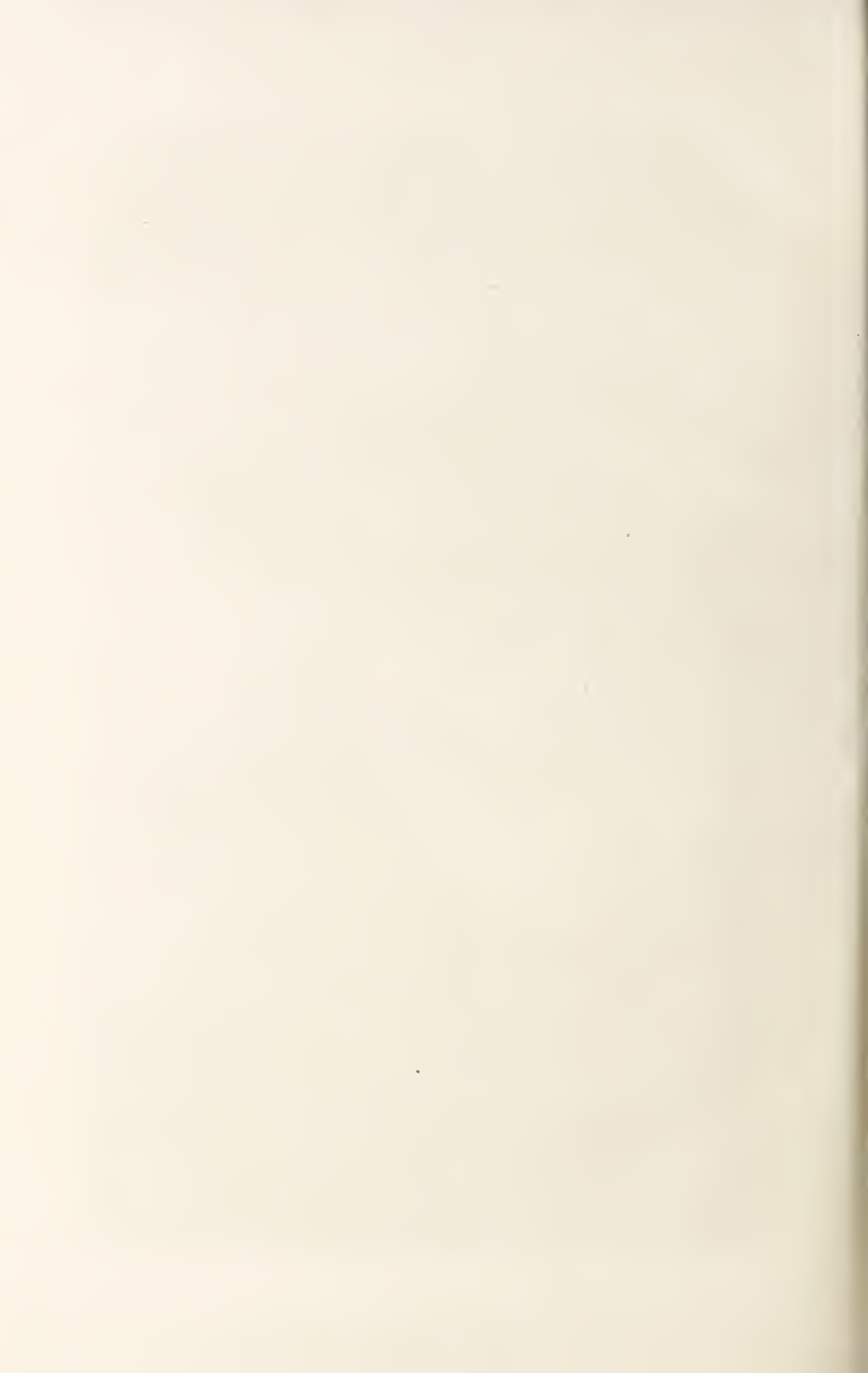
*Heart Lake* (elevation 7,469 feet).—This beautiful little lake lies in a deep depression at the eastern foot of Mount Sheridan and Red Mountain. It is about  $3\frac{1}{2}$  miles long from northwest to southeast and not quite 2 miles broad. Its bottom is of lava gravel, rather shallow near shore but becoming deep in the middle. It is drained by Heart River, a considerable tributary of Snake River, without falls, and said to be well stocked with fish. Near the head of the lake and in the lake are numerous geysers and hot springs. In the lake were found trout (*Salmo mykiss*), slightly afflicted with the same worm that is found in the Yellowstone. These trout were most numerous about the mouth of Witch Creek, and several were taken without the fly after chubs had been thrown into the lake to lure them. These chubs are eagerly swallowed by the trout. Besides these trout, a sucker (*Catostomus ardens*), chub (*Leuciscus atrarius*), shiner (*Leuciscus hydrophlox*), and minnow (*Agosia nubilata*), are found in the lake. All of these except the trout ascend Witch Creek. A blob (*Cottus*) is also in the lake, but we were unable to catch specimens of it. There is plenty of fish-food in the lake and the water is not very cold, its temperature varying according to the nearness to the hot springs and geysers.

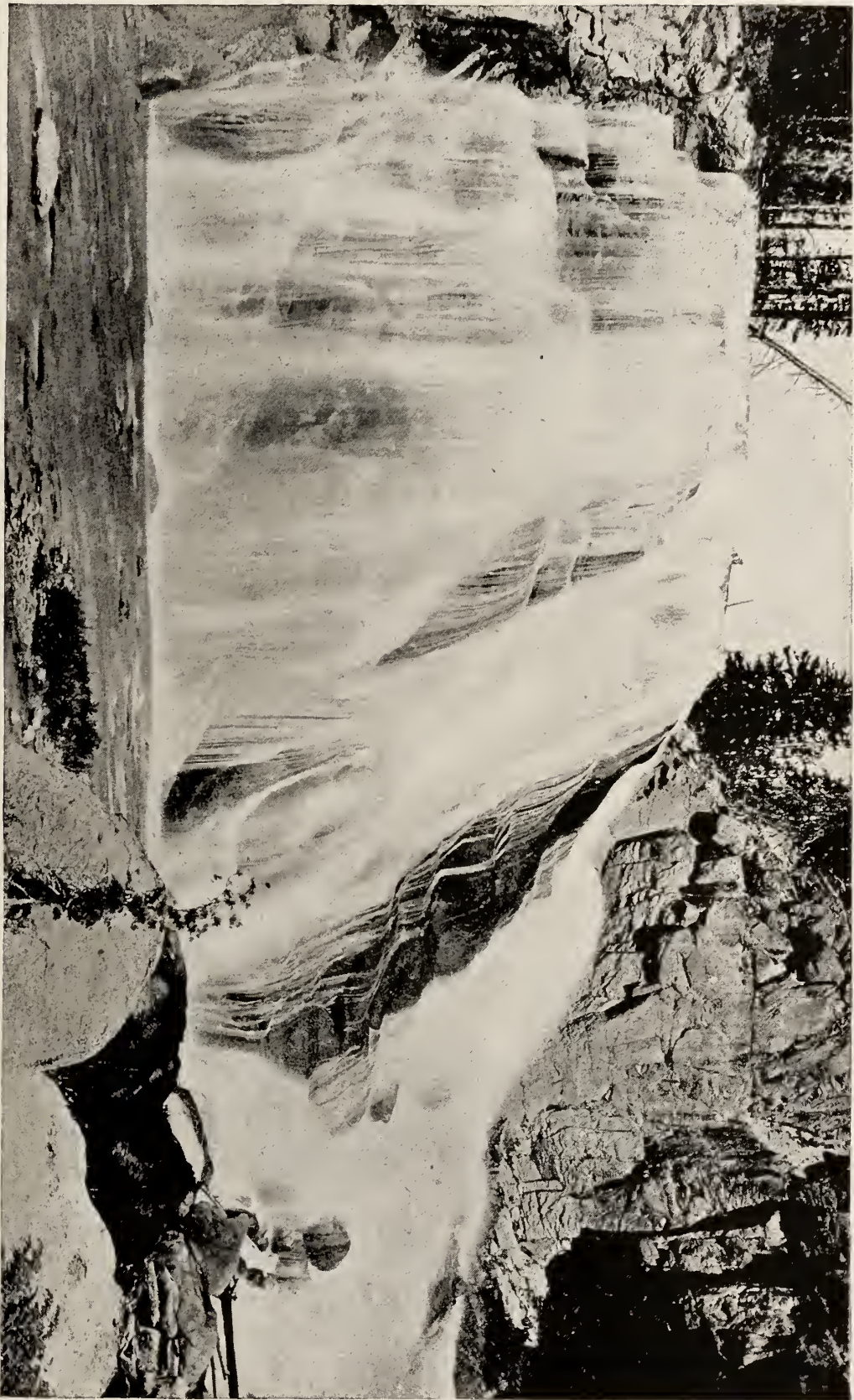
*Witch Creek* has its rise 2 or 3 miles above the lake, in the singular collection of geysers, hot springs, and steam holes known as "Factory Hill." Its water is at first scalding hot, but it gradually cools, receiving the waters of one cold tributary as large as itself. The chubs ascend until they reach water fairly to be called hot, and the sucker is not far behind. The lower course of Witch Creek winds through grassy meadows with a bottom of fine lava gravel and sand. In this part of the stream fishes are excessively abundant, chiefly suckers and chubs. As already noticed, the suckers are here infested by a very large parasitic worm, but no worms were seen in the chubs. Witch Creek has at its mouth a temperature of about 75° F.

*Shoshone Lake* (elevation 7,740 feet) has a length of about  $6\frac{1}{2}$  miles and a width of one-half to  $4\frac{1}{2}$  miles, it being dumbbell-shaped or constricted in the middle. Its area is about 12 square miles. At the head of the upper and smaller lobe of the lake is Shoshone Creek, fed by numerous hot springs and geysers. No hot springs exist on the

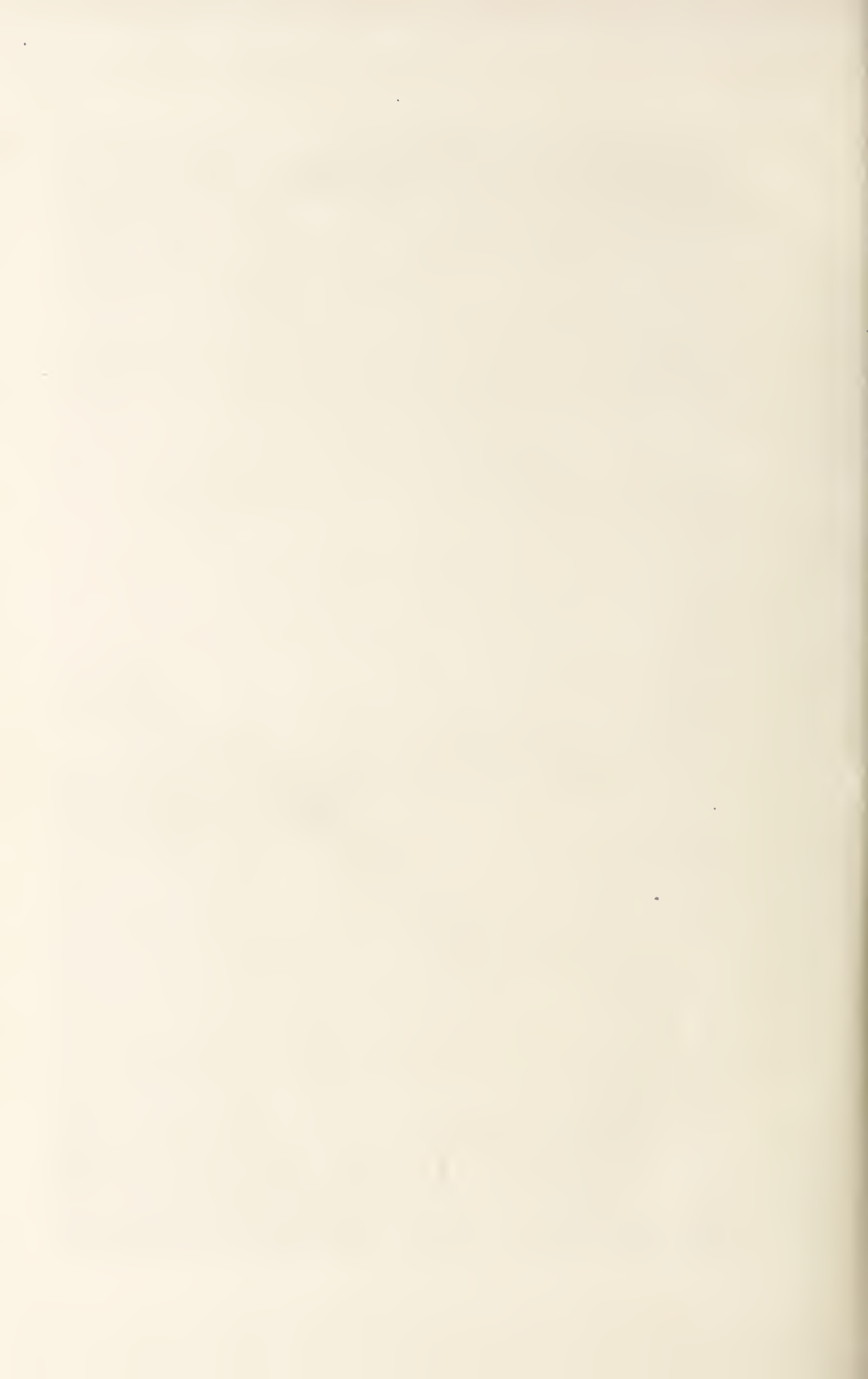


VIRGINIA CASCADE OF GIBBON RIVER. (See page 50.)





GIBBON FALLS OF GIBBON RIVER. (See page 59.)





KEPLER'S CASCADE OF FIREHOLE RIVER. (See page 59.)



RAPIDS ON LEWIS FORK OF SNAKE RIVER. (See page 60.)



lower part of the lake. Its shores are mostly bold, rocky, and densely wooded, the eastern shore being especially abrupt, and the bottom is there made by large boulders of lava. There are no fishes in the lake. Along the eastern shore there is little fish-food, the lava rocks being barren, but the amount of water plants, lily-pads, etc., drifted on shore by the wind shows that a different condition must exist at the other end of the lake. Some crustacea and insects were noticed even on the east side. The lake is clearer and colder than either Yellowstone Lake or Heart Lake, and its mountainous shores render it extremely picturesque.

*Heron Creek* is a small grassy stream suitable for trout, flowing into the northeast angle of Shoshone Lake. It has now no fish life.

The outlet of Shoshone Lake is called *Lewis River*, a broad, swift, very clear stream, well provided with fish-food. This beautiful stream flows with a sluggish current for about 3 miles, where it expands suddenly forming the following lake:

*Lewis Lake* (elevation 7,720 feet).--This lake occupies a rounded basin with rather low banks. It is pear-shaped, about 3 miles long by 2 broad, very clear and cold and apparently in every way suited for trout. Its bold shores are heavily wooded and without tributary streams. A few hot springs, not seen by us, enter it on the western side. Below Lewis Lake, Lewis River enters a deep and narrow cañon, very rarely visited, and which lack of time prevented us from examining. According to Mr. Arnold Hague, there is at the head of this cañon a cascade of about 80 feet, of which 20 feet at the top is perpendicular. Toward the end of the cañon, above its junction with Snake River, is another cascade of some 50 feet in height, concerning which we were unable to secure information. Fishes are unable to ascend the upper fall, and perhaps the lower one also.\* Near the lower fall is the mouth of Crawfish Creek, which has a considerable cascade called Moose Fall. In this creek crawfishes (*Astacus*) are said to abound.

None of the streams in the valley of Falls River in the southwestern part of the Park were examined. This region is said to be rather level, full of ponds, marshes, and springs. Here trout are reported to be very abundant.

Trout were also procured by Mr. E. R. Lucas, of the Fish Commission, in Howard's Creek, Idaho. Mr. Lucas gives us the following notes:

"On October 14, I collected 1,000 black-spotted trout from Howard's Creek, and on October 16 I planted them in the East Fork of the Gardiner River (Lava Creek) above the falls. Howard's Creek is the headwater of Henry's Lake. It rises in the mount-

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\* Prof. Frank H. Bradley (Report U. S. Geol. Survey, 1872, p. 256, *vide* Gannett), thus speaks of Lewis River:

"In descending from Lake Lewis, the party found the river-banks low and rocky for a short distance before the stream enters a cañon with walls 150 to 200 feet high, in which were encountered sharp rapids and a vertical fall of about 30 feet. Then for a mile or two the slopes are gradual with narrow, swampy bottoms along the river. About 3 miles below the lake high, rocky banks indicate the approach to a deep cañon which really commences at about  $3\frac{1}{2}$  miles, with perpendicular walls on both sides inclosing a narrow channel with a rapidly-sloping rocky floor, in some places partially obstructed by huge tumbling masses of rock, but apparently without any accumulation of gravel. Considerable rapids occur through nearly the whole cañon, and one fall of nearly 50 feet was noticed. The cañon deepens rapidly to from 700 to 800 feet, with width of less than half the depth at the deepest precipitous portions. \* \* \* About 3 miles down it reaches its culmination and is truly grand. It has none of the brilliancy of coloring so characteristic of the Yellowstone Cañon, but the sombre tints of its gray, brown and dark-red lichen-covered rocks, variegated with smaller patches of green and yellow, constitute a peculiar style of beauty and add greatly to the effect of its narrow dark depths."

ain (Continental Divide) and flows about 2 miles, emptying into Henry's Lake. Howard's Creek is very small, averaging not more than 6 feet in width, and 6 to 12 inches deep. The bottom of this stream is mostly covered with small stones, in places a mud bottom. It contains no vegetable growth, except grass along its banks. There are no fish in this stream except trout, ranging from 1 inch to 4 inches in length. I caught 1,000 of these fish in about one hour and a half. It is impossible to estimate the number of trout that could be caught in this stream."

The following is a classified list of the lakes and streams in the Park (including a few outside its southern boundary) suitable for trout. Those in which trout are supposed not to exist are indicated by a star.

Upper Yellowstone River:

- Atlantic Creek.
- Jay Creek.
- Bridger Lake and Creek.
- Falcon Creek.
- Thoroughfare Creek.
- Escarpment Creek.
- Cliff Creek.
- Lynx Creek.
- Phlox Creek.
- Mountain Creek.
- Badger Creek.
- Trapper's Creek.

Yellowstone Lake:

- Beaverdam Creek.
- Rocky Creek.
- Elk Trail Creek.
- Chipmunk Creek.
- Riddle Lake and Solution Creek.
- Arnica Creek with Beech Lake.
- Columbine Creek.
- Clear Creek.
- Turbid Lake\* and Bear Creek.
- Pelican Creek.

Lower Yellowstone River:

- Sour Creek.
- Trout Creek.
- Alum Creek.
- Crystal Lake and Cascade Creek.\*
- Broad Creek.\*
- Deep Creek.\*
- Antelope Creek.
- Tower Creek.\*
- Lamar River.
- Cold Creek.
- Willow Creek.
- Timothy Creek.
- Miller Creek.
- Calfee Creek.
- Cache Creek.
- Soda Butte Creek, Pebble Creek, Amphitheatre Creek.
- Slough Creek with Buffalo Creek, Lake Abundance, etc.
- Hellroaring Creek.

LOWER FALLS OF FIREHOLE RIVER. (See page 59.)





## Lower Yellowstone River—Continued.

Black-Tail Deer Creek.

Gardiner River.

Lava Creek, Lupine Creek.

Obsidian Creek\* (with Twin Lakes,\* Obsidian Lake,\* Beaver Lake,\* Lake of the Woods\*),

Winter Creek,\* Straight Creek,\* with Grizzly Lake.\*

Indian Creek.\*

Panther Creek.\*

Fawn Creek.\*

Glen Creek,\* with Swan Lake.\*

## Gallatin River :

Gallatin Lake.

Fan Creek.

Grayling Creek.

## Madison River :

Gibbon River:\* with Grebe Lake.\*

Solfatara Creek.\*

Cañon Creek.

Firehole River.\*

Madison Lake.\*

Spring Creek.\*

Iron Spring Creek.\*

Little Firehole River.\*

Fairy Creek.\*

Goose Lake.\*

Sentinel Creek.\*

Nez Percé Creek\* (with Aspen,\* Spruce\* and Magpie\* Creeks).

Cougar Creek.

Maple Creek.

Gneiss Creek.\*

## Snake River :

Fox Creek.

Crooked Creek.

Sickle Creek.

Pacific Creek.

Heart Lake and Heart River.

Witch Creek.

Beaver Creek.

Surprise Creek.

Basin Creek.

Coulter's Creek, with Harebell and Wolverine Creeks.

Red Creek.

Forest Creek.

Lewis River.\*

Shoshone Lake,\* with Shoshone Creek,\* Moose Creek,\* and Heron Creek.\*

Lewis Lake.\*

Crawfish Creek.\*

Falls River with Benla,\* Hering\* and Grassy\* Lakes.

Mountain Ash Creek.

Beehler River.













